FINAL REPORT

Comparative Demonstration of Active and Semi-Passive In Situ Bioremediation Approaches for Perchlorate-Impacted Groundwater (Longhorn Army Ammunition Plant)

ESTCP Project ER-0219

JANUARY 2009

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Environmental Security Technology Certification Program

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **JAN 2009**	2. REPORT TYPE **N/A**	3. DATES COVERED **-**

4. TITLE AND SUBTITLE **Comparative Demonstration of Active and Semi-Passive In Situ Bioremediation Approaches for Perchlorate-Impacted Groundwater (Longhorn Army Ammunition Plant)**	5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Geosyntec Consultants**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S) 11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES
The original document contains color images.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**UU**	**329**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

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LIST OF ACRONYMS

ASTM	American Standard for Testing and Materials
BAZ	biologically active zone
bgs	below ground surface
BOD	biological oxygen demand
CDHS	California Department of Health Services
CES	Complete Environmental Service
cis-1,2-DCE	cis-1,2-Dichloroethene
cm/sec	centimeters per second
COD	chemical oxygen demand
^{o}C	degrees Celsius
Dem/Val	demonstrate/validate
DGGE	denaturing gradient gel electrophoresis
DHG	Dissolved hydrocarbon gases
DNA	deoxyribonucleic acid
do	dissolved oxygen
DoD	Department of Defense
DOE	Department of Energy
DOT	Department of Transportation
EISB	enhanced *In Situ* bioremediation
ESTCP	Environmental Security Technology Certification Program
ft/ft	feet per feet
ft^2	square feet
GAO	Government Accountability Office
gpm	gallons per minute
HASP	Health and Safety Plan
ID	inside diameter
K	hydraulic conductivity
LHAAP	Longhorn Army Ammunition Plant
m^2	square meters
MCL	maximum contaminant levels
MEAL	methanol, ethanol, acetate and lactate
mg/L	milligrams per Liter
MPN	probable number counts
MSDS	safety data sheet
mV	millivolts
NASA	National Aeronautics and Space Administration
NFESC	Naval Facilities Engineering Service Center
NPV	net present value
o&m	Operation and Maintenance
OM&M	Operation, Maintenance and Monitoring
ORP	oxidation reduction potential

LIST OF ACRONYMS (Continued)

OSHA	Occupational Safety and Health Administration
PAL	provisional action level
PCR	polymerase chain reaction
ppb	parts per billion
PQL	practical quantitation limit
P&T	Pump and Treat
RCRA	Resource Conservation and Recovery Act
QAPP	Quality Assurance Project Plan
SAP	Sampling and Analysis Plan
SERDP	Strategic Environmental Research and Development Program
SIC	Standard Industrial Classification Code
SIU	Southern Illinois University
STL	Severn Trent Laboratories
TCE	Trichloroethene
TDS	total dissolved solids
TNRCC	Texas Natural Resource Conservation Commission
TNT	2, 4, 6- trinitrotoluene
UCB	University of California at Berkeley
USEPA	United States Environmental Protection Agency
VOC	Volatile organic compounds
µg/L	micrograms per Liter
µmol/L	micromoles per Liter

Acknowledgements

Funding of this work was provided by the Department of Defense (DoD), Environmental Security Technology Certification Program (ESTCP). The authors wish to thank Dr. Andrea Leeson and Dr. Jeffery Marqusee of ESTCP and Bryan Harre of the Navel Facilities Engineering Service Center (NFESC) for their support during the demonstration and for comments provided on the work and on the report. Field work was organized and conducted by David Bertrand, Grant Scholes and Natasha Barros of Geosyntec and by Bill Corrigan of CES Environmental. Microbial characterization and chemical analysis were conducted by Dr. John Coates of BioInsite, LLC. The work would not have been possible without the cooperation and support from many individuals at the U.S. Army and the U.S. Army Corp of Engineers including; Andy Abrochta, Cliff Murray and Rose Zeiler.

Executive Summary

Perchlorate is an inorganic anion that consists of chlorine bonded to four oxygen atoms. It is a primary ingredient in solid rocket propellant and has been used for decades by Department of Defense (DoD), National Aeronautics and Space Administration (NASA), and the defense industry in the manufacturing, testing, and firing of rockets and missiles. Perchlorate exhibits high solubility and mobility in water and has been identified in groundwater at numerous sites across the U.S. at concentrations above the upper limit of U.S. Environmental Protection Agency's (USEPA's) provisional cleanup guidance for perchlorate of 18 parts per billion (ppb). Enhanced *In Situ* bioremediation (EISB) of perchlorate impacted groundwater offers the potential to treat and destroy perchlorate without the need for disposal of residuals containing recovered perchlorate (as with above ground ion exchange) or extensive above ground treatment (as with *Ex Situ* bioremediation).

This Report describes work conducted to demonstrate/validate the use of a semi-passive EISB approach at the Longhorn Army Ammunition Plant (LHAAP) in Texas. The goal of this work was to demonstrate the efficacy of this approach at a scale that is large enough to generate accurate full-scale design and cost information for widespread technology consideration and application at DoD and related sites.

The semi-passive EISB approach involves periodic (e.g., 2 or 3 times per year) delivery of electron donor to create a biologically active zone or biobarrier across a perchlorate plume, for the purposes of promoting perchlorate biodegradation and controlling plume migration. The semi-passive biobarrier approach involves the use of alternating extraction and injection (electron donor delivery) wells installed across a perchlorate plume. To add and mix the electron donors across the plume, groundwater is periodically extracted, amended with electron donor, and recharged to the aquifer. Once electron donor is delivered, recirculation is shut off, and the electron donor in the subsurface groundwater promotes *In Situ* biological treatment of the perchlorate. Biomass generated by each batch injection of electron donor will decay over time and help extend the period between batch injections. The semi-passive approach can also be used to distribute electron donor in source areas, or throughout other target treatment zones.

The following technical conclusions have been made based on the results of the field demonstration phase of the work:

1. The data demonstrate that significant reductions in perchlorate concentrations can be achieved using a semi-passive biobarrier system for *In Situ* bioremediation of perchlorate. At the end of the demonstration, perchlorate concentrations were reduced from levels over 800 μg/L to less that 4 μg/L in 10 of 13 shallow wells within and downgradient of the biobarrier and the concentrations in the other wells ranged from 7 to 10 μg/L. The average concentration of perchlorate in shallow wells within and downgradient of the biobarrier following the final addition of electron donor was 3.4 μg/L.

2. The ORP of groundwater samples collected prior to addition of electron donor were generally high (greater than 150 mV) and were reduced significantly following addition of electron donor. ORP can provide a simple real time field measurement of the extent of the distribution of electron donor influence.

3. Each cycle of addition of electron donor achieved a greater and more sustained reduction in perchlorate and ORP than the previous injection. The greater impact of the third and final injection of electron donor is likely due to a combination of factors including: 1) the improved distribution of electron donor provided by the modified recirculation pattern used; 2) the residual beneficial impacts of the first and second addition of electron donor including reducing minerals in the geological media and growing biomass which can act as a long-term residual source of electron donor; and 3) the larger quantity of electron donor used during the third injection.

4. Following the final injection of electron donor, the concentrations of iron in groundwater samples consistently increased within the area of the biobarrier relative to the upgradient concentrations, but the concentrations in wells downgradient of the biobarrier (i.e., 30 feet downgradient of the centerline of the recirculation wells) declined significantly. Similar trends were observed for manganese which increased within the biobarrier but generally decline in concentrations downgradient. The concentration of arsenic also increased within the biobarrier but declined significantly within 30 feet downgradient of the biobarrier.

Based on the experience and observations made during the demonstration, all of the performance objectives for the demonstration were achieved. The performance objectives were demonstrated as follows:

- **The ease of installation of electron donor delivery components** - This objective was achieved based on experience with the actual installation of the electron donor delivery system at the LHAAP Site. The equipment for the injection of electron donor and short-term circulation of groundwater was readily available through local drillers and plumbing suppliers. The procedures used to install the wells, pumps and piping were standard for local licensed drillers and the procedures were simple enough to be conducted by field technicians with minimal special training.

- **The ease of electron donor delivery events** - This objective was achieved based on experience of field staff with the actual electron donor delivery events who reported that the procedures were simple and completed with minimal training and effort.

- **The enhancement of microbiological activity** - This objective was achieved based on the results of chemical and geochemical characterization. Groundwater monitoring data for chemical and geochemical parameters demonstrated that electron donor addition enhanced microbiological activity in the treatment zone. Significant and sustained reductions in ORP were observed following addition of electron donor and provide the

first indication that biological activity was enhanced by the addition of electron donor. The significant and sustained reductions in perchlorate concentrations in groundwater observed following addition of electron donor provide additional indication that biological activity was enhanced by the addition of electron donor and that this biological activity included microorganisms capable of degradation of perchlorate.

- **The ease of performance monitoring and validation** - This objective was achieved based on the data obtained during the demonstration. The quality of the data obtained and the ability to interpret this data and quantify biodegradation with confidence demonstrates that the performance monitoring network allowed for straightforward data collection, interpretation and validation.

- **The reduction in perchlorate concentrations** - This objective was achieved based on groundwater sampling of performance monitoring wells which demonstrated that the average perchlorate concentrations were reduced to below the practical quantitation limit (PQL) of 4 µg/L.

- **The radius of influence and distance for degradation** - This objective was achieved based on groundwater sampling results from performance monitoring wells during the tracer tests and following electron donor delivery cycles which demonstrated that the radius of influence for electron donor extends between all recirculation wells and that perchlorate was degraded before groundwater reached downgradient performance monitoring wells.

An assessment of the costs to implement EISB for perchlorate impacted groundwater using the semi-passive approach was also conducted. A cost model was developed for a template site based on a typical site with perchlorate impacted shallow groundwater. Using these site conditions, the cost model identifies the major cost drivers for the semi-passive approach and provides an estimate of costs for the capital, o&m, and long-term monitoring. A cost estimate was also prepared for a conventional pump and treat system to provide a point of comparison with the semi-passive EISB approach. The cost model focused on treatment of a contaminated plume of groundwater and did not include costs for possible source zone treatment. The cost assessment includes estimates of the Net Present Value (NPV) of future costs to help assess the life-cycle costs.

The template site base case design incorporates one biobarrier on the downgradient edge of a plume to treat water as it flows across the line of the biobarrier. Based on the groundwater seepage velocity of 10 meters per year (m/yr) or 33 feet per year (ft/yr), a plume that extends for 240 meters (800 feet) along the direction of groundwater flow and the assumed need to flush two pore volumes of clean water through the impacted aquifer to achieve clean up standards, it would be expected to take approximately 48 years for the plume to be treated in the base case.

The perchlorate treatment objective that was used for the template site was based on the chronic exposure reference dose (and the resulting drinking water equivalent concentration) selected by

the U.S. Environmental Protection Agency in 2005 (http://www.epa.gov/iris/subst/1007.htm) of 0.0245 milligrams per liter (mg/L). A lower treatment objective would increase the costs associated with the remediation. The semi-passive EISB approach can achieve low treatment criteria (i.e., below 0.004 mg/L) but to achieve lower target treatment criteria, a higher safety factor would be required in the design and operation of each of the remedy such that pockets or layers of low hydraulic conductivity geological material containing untreated groundwater with some perchlorate do not remain or transmit perchlorate in groundwater following treatment and the system may need to be operated for a longer period of time.

The costs to implement semi-passive EISB for perchlorate impacted groundwater will vary significantly from site to site. The key costs drivers are listed below.

- The dimensions and depth of the plume to be treated.
- Ambient groundwater velocity.
- Hydraulic conductivity (K) of the geological media containing the impacted groundwater and the degree of variation in the K of different layers in the geological media.
- Concentration of perchlorate and other electron acceptors in impacted groundwater and the target treatment concentration.

The capital and operation and maintenance (o&m) cost for the semi-passive EISB system and for a comparable pump and treat system at the template site are presented in the table below.

	Semi-Passive Biobarrier	Pump and Treat
Capital Costs	$430,000	$490,000
Annual o&m Costs	$39,000	$74,000
NPV of 30 Years of o&m Costs	$780,000	$1,470,000
NPV of 30 Years of Total Remedy Costs	$1,560,000	$2,310,000
Total 30-Year Remedy Costs	$2,060,000	$3,160,000

1. INTRODUCTION

This Final Report has been prepared by Geosyntec Consultants (Geosyntec) for the Environmental Security Technology Certification Program (ESTCP) to present the results of the semi-passive EISB demonstration that was conducted at the LHAAP in north-eastern Texas. This work was conducted as part of ESTCP Project ER-0219, "Comparative Demonstration of Active and Semi-Passive *In Situ* Bioremediation Approaches for Perchlorate Impacted Groundwater".

Section 1 of this Report presents background information and summarizes the objectives of the demonstration. Section 2 describes the semi-passive bioremediation technology demonstrated in this work. Section 3 presents the performance objectives for the demonstration. Section 4 presents information on the LHAAP Site where the demonstration was conducted. Section 5 presents the test design and results of the demonstration. Section 6 presents the results of the performance assessment. Section 7 presents the results of a cost assessment of the technology and Section 8 discusses potential implementation issues with technology.

1.1 BACKGROUND

Perchlorate is an inorganic anion that consists of chlorine bonded to four oxygen atoms (ClO_4^-). It is a primary ingredient in solid rocket propellant and has been used for decades by Department of Defense (DoD), NASA, and the defense industry in the manufacturing, testing, and firing of rockets and missiles. On the basis of 1998 manufacturer data, it is estimated that 90 percent of the several million pounds of perchlorate produced in the United States each year is used by the military and NASA. Private industry has used perchlorate to manufacture products such as fireworks, safety flares, automobile airbags, and commercial explosives.

Perchlorate exhibits high solubility and mobility in water and is very stable, being degraded only under anaerobic conditions. Consequently, when perchlorate is released into a typical groundwater or surface water environment, it tends to persist and can migrate to great distances (many miles) in groundwater, as has been observed at many sites. Perchlorate released to the subsurface many decades ago can also be retained in the pore spaces of low permeability materials such as silts and clays, representing a long term threat to groundwater and surface water. This can be particularly problematic in areas where artificial recharge has resulted in rising groundwater elevations, solubilizing perchlorate previously held within the unsaturated soil matrices.

The frequency of detection of perchlorate in groundwater and surface water has been steadily increasing since its initial identification as a chemical of regulatory concern in 1997. To date, U.S. federal and state regulatory agencies have reported detecting perchlorate in soil, groundwater, surface water, and/or drinking water at almost 400 sites in 35 states, the District of Columbia, and two U.S. commonwealths (United States Government Accountability Office [GAO], 2005). Detections were reported for military installations, commercial manufacturers,

public water systems, private wells and residential areas. While concentrations exceeded part per million (ppm) levels at some military and manufacturing sites, approximately two-thirds of the sites (249 of 395) reported perchlorate levels at or below 18 micrograms per Liter (µg/L) the upper limit of USEPA's provisional cleanup guidance for perchlorate. More than half of the sites (224 of 395) were located in Texas and California, where regulatory agencies have conducted broad investigations to determine the extent of perchlorate in the environment. The highest concentrations of perchlorate (more than 500,000 µg/L for 11 different sites) were reported for sites in Arkansas, California, Nevada, Texas, and Utah, primarily related to rocket manufacturing or to the manufacture of perchlorate itself (GAO, 2005).

Perchlorate impacts at 110 of the sites was reportedly due to activities related to defense and aerospace, such as propellant manufacturing, rocket motor research and test firing, or explosives disposal. At 58 sites, perchlorate impacts were reportedly from manufacturing and handling, agriculture, and a variety of commercial activities such as fireworks and flare manufacturing. Interestingly, the source of the perchlorate was either undetermined or naturally occurring at more than 227 sites, of which 105 sites are located in the Texas high plains region, where perchlorate concentrations range from 4 to 59 µg/L (GAO, 2005).

The source of perchlorate in water supplies has typically been attributed to DoD, NASA and/or defense contractor facilities that have used ammonium perchlorate (AP) in rocket and missile propellants. However, in recent years, the reporting of sites impacted by perchlorate from non-military activities, including agriculture, mining and construction, fireworks displays, and production and use of electrochemically-produced (ECP) chlorine chemicals, has dramatically increased, changing the paradigm that perchlorate is solely a DoD cleanup responsibility.

Conventional technologies for the treatment of perchlorate-impacted groundwater are expensive. In California alone, the costs for remediation of perchlorate-impacted groundwater are expected to be in the billions of dollars, the cost of which may jeopardize major DoD and propulsion contractor production programs. Of the technologies being developed, bioremediation is among the most promising, because it has the potential to destroy perchlorate rather than transferring it to another waste stream (e.g., impacted resin or brine) requiring costly treatment or disposal. Recent bench- and small-scale field demonstrations are providing strong evidence that In Situ bioremediation can provide a less costly and less Operation and Maintenance (o&m)-intensive approach to remediating perchlorate-impacted groundwater. Specifically, EISB has potential to both destroy perchlorate source areas and to control the migration of the perchlorate plumes that are threatening drinking water supplies.

Enhanced *In Situ* bioremediation of perchlorate impacted groundwater offers the potential to treat and destroy perchlorate without the need for disposal of residuals containing recovered perchlorate (as with above ground ion exchange) or extensive above ground treatment (as with *Ex Situ* bioremediation). One of the main factors that affects the success and cost of *In Situ* bioremediation systems is the effectiveness of nutrient (electron donor) delivery and mixing in the subsurface. A variety of active, semi-passive and fully passive electron donor delivery

systems have been employed to promote contaminant biodegradation. As further discussed in Sections 2, each of these delivery configurations has associated benefits and limitations with respect to ease of implementation and cost. This Report describes work conducted to demonstrate/validate (Dem/Val) the use of a semi-passive EISB approach at a relatively shallow site at LHAAP in Texas. The results of a second demonstration of the use of an active EISB approach will be presented in a separate report. The goal of the program is to demonstrate the efficacy of both approaches at a scale that is large enough to generate accurate full-scale design and cost information for widespread technology consideration and application at DoD and related sites.

1.2 OBJECTIVES OF THE DEMONSTRATION

The specific objectives of this technology demonstration are:

1. Demonstrate that perchlorate can be biodegraded *In Situ* to acceptable levels (i.e., the practical quantitation limit; PQL) using *In Situ* bioremediation with a semi-passive electron donor delivery methodology;

2. Evaluate the effectiveness of the electron donor delivery approach under *In Situ* conditions, and generate design and performance data for full-scale application using this approach (e.g., cost per unit area or unit volume groundwater treated);

3. Evaluate the effects of the electron donor delivery approach on the acclimation, development and stability of the *In Situ* microbial communities;

4. Evaluate the effects of the electron donor delivery approach on groundwater quality (e.g. production of sulfides or methane, or mobilization of dissolved metals), and assess its suitability for use in drinking water aquifers (to address direct regulatory concerns); and

5. Identify design and operational factors that influence successful implementation and continued operation of the *In Situ* bioremediation approach.

One of the advantages of the semi-passive electron donor amendment approach over a passive injection approach is the potential to have less impact on secondary water quality characteristics because large quantities of electron donor are not injected at one time. The approach taken in the demonstration at the LHAAP began with the addition of modest amounts of electron donor to evaluate the impact on perchlorate concentrations and secondary water quality characteristics. As a better understanding of the impact of electron donor was gained, the loading was increased to achieve the perchlorate reduction objectives with the least possible impact on secondary water quality characteristics.

1.3 REGULATORY DRIVERS

The USEPA and various states are currently evaluating perchlorate in drinking water but Interim guidelines have been published and range between 4 and 18 μg/L. These concentrations are considerably less than the concentrations present in groundwater at many sites throughout the United States. While *Ex Situ* treatment alternatives exist for perchlorate-impacted groundwater, they are often cost intensive, and therefore, this demonstration seeks to validate a more cost-effective technology that can meet the pending remediation goals. For this demonstration, the remediation target will be reduction of perchlorate concentrations to the current common practical quantitation limit (PQL), which is 4 μg/L in most jurisdictions.

2. TECHNOLOGY

This Section describes the semi-passive EISB technology which is the subject of the demonstration described in this Report. Section 2.1 provides a description of the technology; Section 2.2 describes the development of the technology; and Section 2.3 discusses the advantages and limitations of the technology.

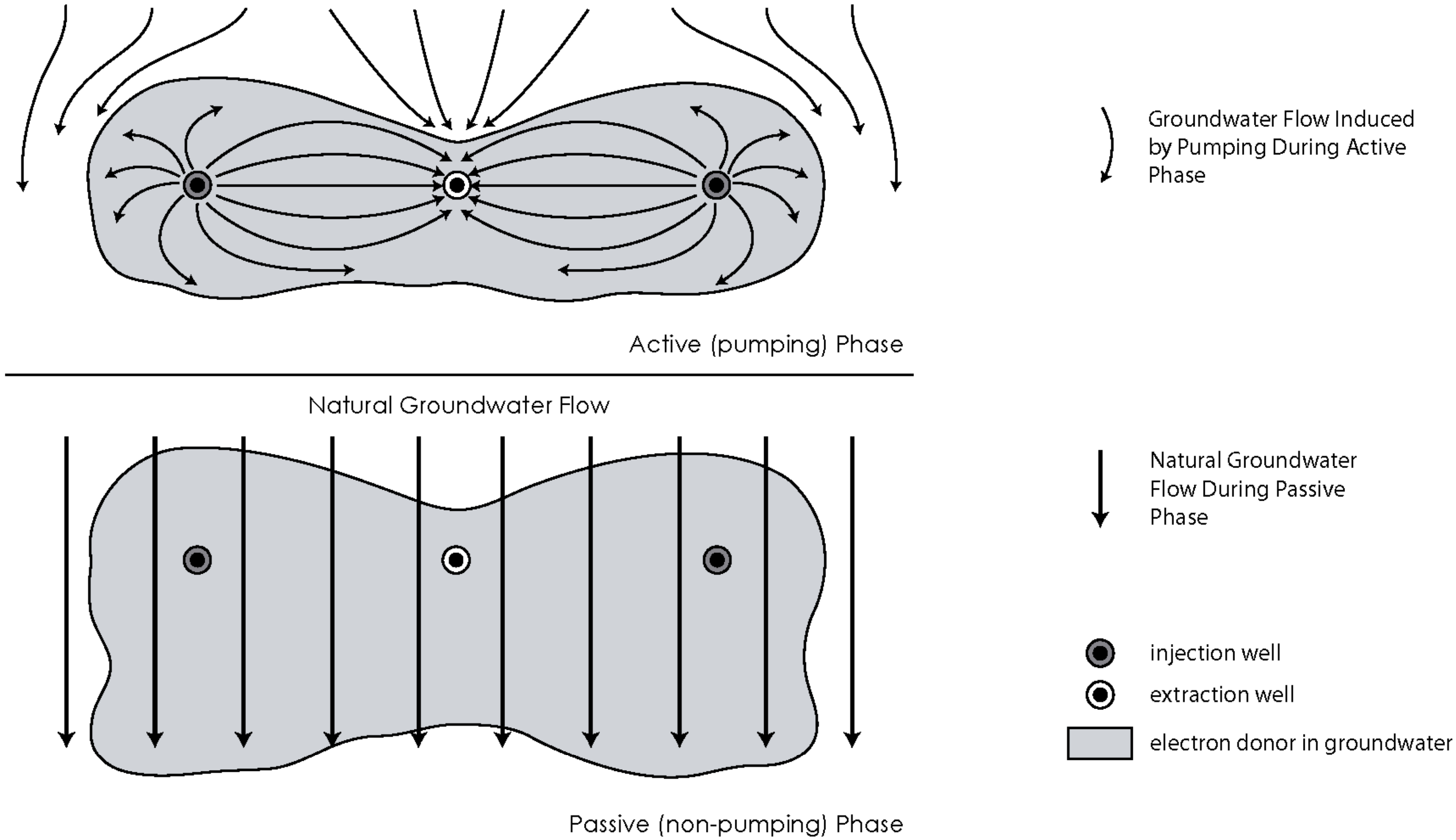
2.1 TECHNOLOGY DESCRIPTION

Enhanced *In Situ* bioremediation has proven to be a cost effective approach for the treatment of perchlorate impacted groundwater under many different site conditions. One of the main factors that affects the success and cost of EISB systems is the effectiveness of nutrient (electron donor) delivery and mixing in the subsurface. A variety of active, semi-passive and fully passive electron donor delivery systems have been employed to promote *In Situ* biodegradation. Each of these delivery configurations has associated benefits and limitations with respect to ease of implementation and cost. Active EISB systems have been shown to be effective (GeoSyntec, 2002) in providing migration control over reasonably wide (and deep) perchlorate plumes with only a few extraction/injection wells. However, due to the continuous operation of active systems, permanent *Ex Situ* infrastructure is required, and o&m costs are high. By comparison, passive systems employing slow-release electron donors do not require permanent *Ex Situ* infrastructure and minimize short term o&m costs, but the tight spacing of the injection points or wells makes the capital costs of the installations prohibitive for large and/or deep plumes. Longer term o&m costs for reinjection of additional electron donor required every 2 to 4 years can also be high. Passive systems also involve injecting large quantities of electron donor at one time and can reduce the hydraulic conductivity of the aquifer in and have significant negative impacts on secondary water quality characteristics.

The goal of the semi-passive bioremediation approach is to integrate the best aspects of both the active approach (wider well spacing and less impact on secondary water quality characteristics) and the passive approach (minimal permanent *Ex Situ* infrastructure, lower o&m), in order to optimize the balance of capital and o&m costs for bioremediation deployment.

Semi-passive EISB of perchlorate involves the addition of electron donor on a periodic basis to stimulate natural microbiological populations. Semi-passive EISB approaches are similar to active approaches in that groundwater is recirculated between injection and extraction wells; however, with the semi-passive approach, groundwater is recirculated for an “active phase” of a limited duration (e.g., several days to several weeks) to distribute the electron donor, and then the recirculation system is shut off for a “passive phase” of longer duration (e.g., several months).

Figure 2-1 shows the induced and natural groundwater flow patterns during the active and passive phases of a semi-passive system. In this case, the injection and extraction wells are configured to create a biobarrier perpendicular to groundwater flow.



Plan View of Groundwater Flow for Semi-Passive Biobarrier System
Site 16 Landfill, LHAAP
Karnack, Texas

Geosyntec consultants

Guelph | December 2008

Figure **2-1**

Plan View.ai

Groundwater extracted from the central well is amended with electron donor and injected into the wells on either side during the active phase. Some of the injected water flows back to the central extraction well and some water moves out in other directions. The ambient flow of groundwater from upgradient of the biobarrier is collected in the central extraction well and some of the flow is diverted around the ends of the biobarrier. During the passive phase, ambient groundwater flow patterns are reestablished and the natural groundwater gradient directs groundwater through the area where the electron donor has been added to the subsurface.

The semi-passive approach can also be used to distribute electron donor in source areas, or throughout other target treatment zones. The semi-passive approach differs from the passive approach in that it relies on some recirculation of groundwater to distribute electron donor and it differs from the active approach in that the recirculation of groundwater is conducted on a periodic and not a continuous basis. The equipment used to implement the semi-passive approach may be mobile and moved from one area to another as required or may be a permanent installation operated on an intermittent basis.

As with the active remediation approaches, the electron donor used for the semi-passive approach must be sufficiently mobile to travel some distance between the injection and extraction wells, in order to achieve the desired electron donor coverage. Soluble electron donors such as sodium lactate, citric acid, or ethanol have been used in field applications, and it may be possible to use mobile forms of emulsified vegetable oil, methyl esters and other slower release forms of electron donor as well. Biomass grows rapidly during the active phase when high concentrations of electron donor are present. During the passive phase, some of the biomass dies, providing a source of electron donor to promote additional microbial degradative activity until the next electron donor addition cycle. The high level of microbial activity also reduces natural minerals in the subsurface, leaving behind reduced minerals which help to maintain reducing conditions after electron donor and biomass has been consumed.

Semi-passive approaches are similar to “passive” bioremediation approaches in that electron donor is added to the subsurface, and the system is allowed to operate predominantly under natural groundwater flow conditions. The “active phase” of the semi-passive approach can allow for a better distribution of electron donor than is possible with the “passive” approach because electron donor is pushed from the injection wells and pulled towards the extraction wells of the groundwater recirculation system. In addition, because the amount of electron donor injected at any one time using the semi-passive approach is typically less than is used in passive systems, there are generally less impacts to secondary water quality and hydraulic conductivity. As with any bioremediation approach, groundwater quality may be adversely impacted by trace constituents present in the electron donors injected. Care must be taken in the selection of electron donors to avoid those that could cause increases in concentrations of dissolved metals or other undesirable constituents.

The semi-passive approach, with periodic operation of a groundwater recirculation system, is less expensive to operate than the active approach because the recirculation system is not

operated on a continuous basis. Periodic operation of the recirculation system will also result in less biofouling of the injection wells than with continuous recirculation. The semi-passive approach also allows for the use of simple equipment such as a trailer-mounted recirculation system that can be moved from one area to another in sequence.

2.2 TECHNOLOGY DEVELOPMENT

Laboratory research in the past has shown that perchlorate biodegradation results from microbially-mediated redox reactions, whereby perchlorate serves as an electron acceptor, and is reduced via chlorate to chlorite. Chlorite then undergoes a biologically-mediated dismutation reaction, releasing chloride and oxygen. A variety of electron donors have been used to stimulate perchlorate reduction using pure or mixed microbial cultures, including alcohols (e.g., ethanol, methanol), organic acids (e.g., acetate, lactate, citrate, oleate), edible oils (e.g., canola oil) and some sugar mixtures (e.g., corn syrup). A variety of microorganisms have been identified as possessing the ability to reduce perchlorate (Coates et al., 1999), including various *Dechlorosoma*, *Dechloromonas*, *Rhodocyclus*, *Azospirillum*, and *Ferribacterium* species, and perchlorate-degrading bacteria have generally been shown to be ubiquitous in subsurface environments.

In 1999, three research groups, including Geosyntec, Envirogen and the Southern Illinois University (SIU; Dr. John Coates) were awarded research grants under the U.S. DoD Strategic Environmental Research & Development Program (SERDP) to evaluate the ubiquity of perchlorate-degrading bacteria in differing geographical, geological and geochemical environments, and to assess the widespread applicability of In Situ bioremediation as a remediation technology for perchlorate-impacted DoD sites. Through this research, laboratory microcosm studies were conducted for more than 12 independent DoD and defense contractor test sites around the nation. Perchlorate biodegradation was observed at essentially all test sites (pH adjustment was required for some test sites), indicating that the distribution of perchlorate-biodegrading bacteria in subsurface environments is widespread. Perchlorate biodegradation was stimulated over site-specific perchlorate concentrations ranging from 250 μg/L to in excess of 660,000 μg/L. Biodegradation typically reduced perchlorate concentrations below the PQL of 4 μg/L, making *In Situ* bioremediation an appropriate technology for site remediation. The key to successfully implementing *In Situ* bioremediation of perchlorate appears to be the addition of appropriate carbon substrates in adequate quantities to reduce competing electron acceptors present in the groundwater (e.g., oxygen and nitrate), and to promote the perchlorate reduction reaction.

While data from bench-scale and small field tests provide evidence that *In Situ* bioremediation has the potential to be a cost-effective remediation alternative for perchlorate-impacted sites, little had been done to critically evaluate *In Situ* bioremediation design configurations that can be widely applied to perchlorate sites. Experience indicates that the greatest factor determining success of *In Situ* bioremediation for perchlorate plumes is effective electron donor delivery. Perchlorate plumes at many DoD sites are very wide and deep, prohibiting standard bioremediation approaches (e.g., injection or emplacement of electron donors using direct push

[e.g., geoprobe] methodologies). Therefore, new electron donor delivery strategies need to be developed for these types of sites.

As indicated earlier, laboratory research programs conducted under the SERDP have conclusively shown that perchlorate-reducing bacteria are ubiquitous, and that electron donor addition can effectively promote perchlorate degradation from a wide range of starting concentrations under varying geochemical conditions. Further to these laboratory studies, GeoSyntec has successfully demonstrated *In Situ* bioremediation of perchlorate in several small-scale field demonstrations at sites in California and Nevada. In one demonstration (SERDP ER-1164), Geosyntec demonstrated perchlorate biodegradation in a deep aquifer (100 feet below ground surface) at the Aerojet Superfund site in California (Cox et al., 2001). Perchlorate concentrations in the groundwater declined from 8,000 μg/L to less than the PQL of 4 μg/L within 35 feet of the electron donor delivery well. More recently, GeoSyntec has successfully demonstrated In Situ bioremediation of perchlorate at a second field demonstration site, reducing perchlorate concentrations from 220 μg/L to <4 μg/L in water being recharged to a drinking water aquifer (at 100 to 150 gallons per minute {gpm}) from an existing *Ex Situ* treatment system. In both studies, ethanol and acetate were shown to be effective electron donors.

2.3 ADVANTAGES AND LIMITATIONS OF THE TECHNOLOGY

The semi-passive EISB technology or approach which is the subject of this demonstration can be used as an alternative to groundwater extraction and above ground treatment (pump and treat) or as an alternative to other EISB approaches (i.e., fully active or passive). Advantages and limitations of the semi-passive EISB approach relative to each of these alternatives are discussed below.

The semi-passive EISB technology has the following advantages over pump and treat technologies which involve long-term groundwater extraction and *Ex Situ* treatment typically using bioreactors (fluidized-bed or fixed-film) or ion exchange:

- Semi-passive EISB will typically have lower capital and o&m costs than alternative technologies which involve groundwater pumping and treatment with high o&m costs.

- Semi-passive EISB will destroy perchlorate rather than simply transferring it to another medium such is accomplished with above ground treatment using ion exchange.

- Semi-passive EISB can directly treat perchlorate in source areas, as well as perchlorate-impacted groundwater as it pass through a linear biobarrier system.

- Semi-passive EISB has the ability to treat co-contaminants such as TCE as part of a single treatment strategy, which is not possible with *Ex Situ* ion exchange or bioreactor technology.

The semi-passive EISB technology has the following limitations over pump and treat technologies:

- Semi-passive EISB may have difficulties distributing electron donor in sufficient amounts to all areas of the aquifer containing perchlorate.

- The effectiveness of semi-passive EISB may be limited by the occurrence of specific geochemical conditions (e.g., high sulfate) that may require larger quantities of electron donor and sulfide production.

- Semi-passive EISB has the potential to adversely impact secondary groundwater quality through mobilization of metals and production of sulfides or methane if excess amounts of electron donor are added.

- The effectiveness of semi-passive EISB may be limited by the presence of co-contaminants that may be inhibitory to biodegradation (e.g., chloroform, hydrogen sulfide).

The semi-passive EISB approach, with periodic operation of a groundwater recirculation system, has the following advantages over passive EISB approaches:

- Semi-passive systems require fewer wells or injection points because the groundwater recirculation provides an induced flow to distribute electron donor across the natural flow of groundwater across greater distances. This factor is particularly relevant when the target treatment zone is deep and the costs to install wells or injection points are high.

- Semi-passive systems do not inject unduly high concentrations of electron donor at one time as is typical with passive systems. The more moderate concentration of electron donor added to semi-passive systems reduces the impacts to secondary water quality characteristics (such as increasing the concentrations of iron and manganese, sulfide and methane) and reduces the tendency for electron donor to be consumed in biological pathways that will not contribute to perchlorate reduction (i.e., methane generation).

- Semi-passive systems do not inject large volumes of oil emulsion that can reduce the hydraulic conductivity of the treatment zone and cause diversion of groundwater around the treatment zone.

The semi-passive approach has the following limitations relative to passive approaches:

- Semi-passive systems normally require the installation of permanent injection wells to allow for periodic amendment of electron donor. Passive systems can use direct push injection points rather than permanent wells.

- Semi-passive systems require periodic re-amendment of the subsurface with electron donor on a more frequent basis than most passive approaches.

The semi-passive approach, with periodic operation of a groundwater recirculation system rather that continuous operation, has the following advantages over active approaches:

- The groundwater recirculation equipment of a semi-passive system does not need to be dedicated to a specific set of injection and extraction wells. The equipment may operate for a few weeks and then be shut off for several months at any specific set of wells. The semi-passive approach can allow for the use of simple equipment such as a trailer-mounted recirculation system that is moved from one area to another in sequence, thus avoiding significant capital costs.

- The operating costs for a semi-passive system are significantly less than for an active system because: 1) the system is not operated continuously and therefore does not incur costs for labor and power during the long “passive phase” of operation; and 2) the injection wells are less susceptible to biofouling because the injection of electron donor is not continuous.

- The equipment required for semi-passive operation can be less complex and is less likely to require complex controls and permitting because of the relatively short duration of operation.

The semi-passive approach has the following limitations relative to active approaches:

- The semi-passive approach results in greater variations in the concentration of electron donor than active systems but not as great as with the passive approach. As discussed earlier, variations in the concentration of electron donor can negatively impact secondary water quality characteristics.

The semi-passive EISB approach incorporates some of the best aspects of both the active approach (wider well spacing and less impact on secondary water quality characteristics) and the passive approach (minimal permanent *Ex Situ* infrastructure, lower o&m), in order to optimize the balance of capital and o&m costs.

3. PERFORMANCE OBJECTIVES

The performance objectives for this Demonstration are shown in Table 3-1 and are discussed in more detail below.

3.1 EASE OF INSTALLATION

The ease of installation of electron donor injection components is an important factor in maintaining low installation costs for the EISB technology. Ideally, the installation can be accomplished using standard, readily available materials and components by contractors without special training or knowledge.

This criterion can be evaluated based on the experience of demonstration operators and the actual availability and costs of installed equipment.

This objective was achieved during the demonstration based on experience with the actual installation of the electron donor delivery system at the LHAAP Site. The equipment required for the semi-passive injection of electron donor and short-term circulation of groundwater was all readily available through local drillers and plumbing suppliers. The procedures used to install the equipment were standard and well established procedures for local drillers and the procedures were simple enough to be conducted by field technicians with training in basic plumbing techniques.

3.2 EASE OF ELECTRON DONOR DELIVERY EVENTS

The ease of electron donor delivery events is an important factor in maintaining low o&m costs. Ideally, the electron donor delivery can be conducted with minimal special training for operators conducting the events, with minimal special equipment and in a short period of time.

This criterion can be evaluated based on the experience of operators and the costs of conducting the electron donor injection events.

This objective was achieved during the demonstration based on experience of field staff with the actual electron donor delivery events. The activities and procedures required for the electron donor delivery events were simple enough to be conducted by field staff with minimal specialized training and effort.

3.3 ENHANCEMENT OF MICROBIOLOGICAL ACTIVITY

The enhancement of microbiological activity is a critical factor to the success of the EISB technology because it is this activity that degrades the perchlorate in the subsurface.

This criterion can be evaluated based on the results of groundwater and soil analyses for geochemical and microbial characterization.

TABLE 3-1: PERFORMANCE OBJECTIVES
Site 16 Landfill, LHAAP, Karnack, Texas

Performance Objectives	Data Requirements	Success Criteria
Qualitative Performance Objectives		
1) Ease of Installation of Electron Donor Delivery Components	Experience of demonstration operators; actual availability and costs of installed equipment	Electron donor delivery system can be readily installed by standard industry procedures/contractors
2) Ease of Electron Donor Delivery Events	Experience of demonstration operators; and costs of events	Electron donor delivery system can be conducted with minimal training and effort
3) Enhancement of Microbiological Activities	Groundwater and soil analyses for geochemical and microbial characterization	Electron donor addition enhances microbiological activity in the treatment zone
4) Ease of Performance Monitoring and Validation	Quality of data and ability to interpret and quantify biodegradation with confidence	Performance monitoring network allows straightforward data collection, interpretation and validation
Quantitative Performance Objectives		
5) Reduction in Perchlorate Concentration	Groundwater sampling of performance monitoring wells	Perchlorate concentrations reduced to practical quantitation limit of 4 µg/L
6) Radius of Influence and Distance for Degeneration	Groundwater sampling of performance monitoring wells	Radius of influence for electron donor addition will extend between injection and extraction wells and perchlorate will be degraded before groundwater reaches the furthest downgradient performance monitoring wells

Notes: µg/L – micrograms per Liter

This objective was achieved during the demonstration based on the results of chemical and geochemical characterization. Groundwater monitoring data for chemical and geochemical parameters demonstrated that electron donor addition enhanced microbiological activity in the treatment zone. Significant and sustained reductions in ORP were observed following addition of electron donor and provide the first indication that biological activity was enhanced by the addition of electron donor. Reduction in sulfate in wells in the immediate vicinity of the electron donor injection points also indicates enhancement of biological activity. The significant and sustained reductions in perchlorate concentrations in groundwater observed following addition of electron donor provide additional indication that biological activity was enhanced by the addition of electron donor and that this biological activity included microorganisms capable of degradation of perchlorate.

3.4 EASE OF PERFORMANCE MONITORING AND VALIDATION

The ease of performance monitoring and validation is an important factor to demonstrate that the objective of perchlorate reduction has been accomplished.

This criterion can be evaluated by assessing the quality of data and ability to interpret and quantify biodegradation with confidence.

This objective was achieved during the demonstration based on the data obtained during the demonstration. The quality of the data obtained and the ability to interpret this data and quantify biodegradation with confidence demonstrated that the performance monitoring network allowed for straightforward data collection, interpretation and validation.

3.5 REDUCTION IN PERCHLORATE CONCENTRATION

The reduction of perchlorate concentrations in groundwater is the most critical objective of demonstration. This is a quantitative objective of achieving an average concentration of perchlorate to the PQL of 4 μg/L.

This objective was achieved based on groundwater sampling of performance monitoring wells which demonstrated that the average perchlorate concentrations were reduced to below the PQL of 4 μg/L in the final sampling event.

This criterion can be assessed based on the results of chemical analysis of groundwater samples collected from performance monitoring wells.

3.6 RADIUS OF INFLUENCE AND DISTANCE FOR DEGRADATION

The radius of influence and distance for degradation of perchlorate is an important factor in determining the effectiveness of the electron donor distribution system.

This criterion can be assessed based on groundwater sampling of performance monitoring wells during the tracer test and following electron donor addition to demonstrate that the radius of

influence for electron donor addition extends between injection and extraction wells and perchlorate is degraded before groundwater reaches downgradient performance monitoring wells.

This objective was achieved during the demonstration based on groundwater sample results from performance monitoring wells during the tracer tests and following electron donor delivery cycles which demonstrated that the radius of influence for electron donor extends between all recirculation wells and that perchlorate was degraded before groundwater reached downgradient performance monitoring wells.

4. SITE DESCRIPTION

This Section presents information on the LHAAP Site where the demonstration was conducted. Section 4.1 describes the site location and history; Section 4.2 describes the site geology/hydrogeology; and Section 4.3 describes the contaminant distribution.

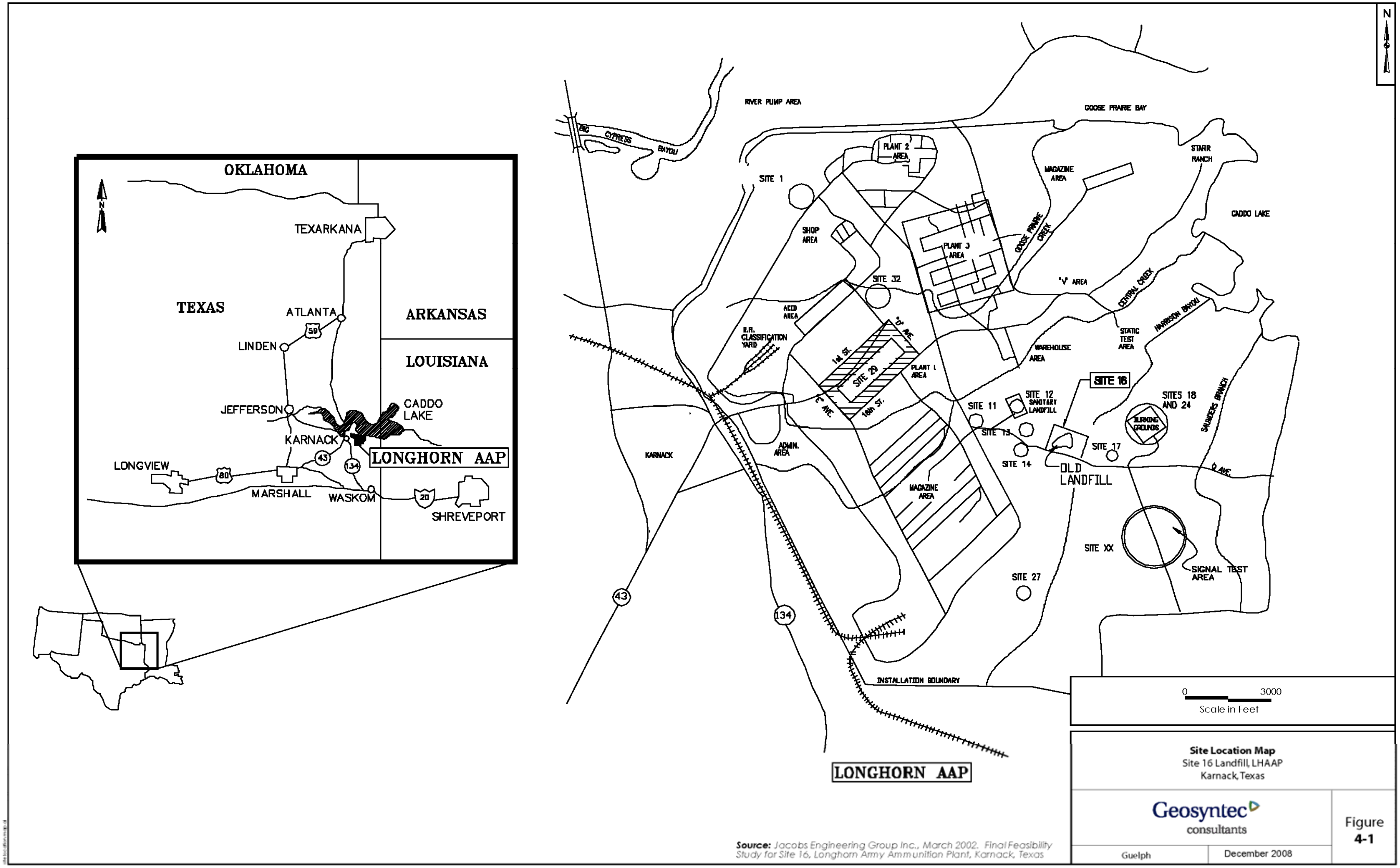
4.1 SITE LOCATION AND HISTORY

LHAAP is located in central east Texas in the northeastern corner of Harrison County. LHAAP occupies nearly 8,500 acres between State Highway 43 at Karnack, Texas, and the western shore of Caddo Lake as shown in Figure 4-1. Figure 4-2 shows a map of the Site 16 landfill at the LHAAP.

Information on the test site history and characteristics is presented in the Final Feasibility Study for Site 16, LHAAP, Karnack, Texas (Jacobs Engineering Group, 2002). Additional information on the geology and hydrogeology is presented in the Final Remedial Investigation (RI) Report Site 16 Landfill (Jacobs, 2000). A summary of the Site history and conditions is presented below.

LHAAP was established in October 1942 with the primary mission to produce 2,4,6-trinitrotoluene (TNT) flake. TNT flake production continued through World War II until August 1945 when the plant went on standby status until February 1952. From 1952 until 1956, pyrotechnic ammunition such as photoflash bombs, simulators, hand signals, and 40-millimeter (mm) tracers were produced at Plant 2. Plant 3 was the site of the rocket motor facility that operated from 1955 to 1965. After that time, the production of pyrotechnic and illuminating ammunition was reestablished. LHAAP became inactive in July 1997, and a year later salvageable property was removed.

All of the production activities at the LHAAP could have contributed to the material disposed of in Site 16. TNT wastewater ash was deposited in the early 1940s. During the 1950s, a large bermed depression in the central section of the currently capped area was reportedly used for disposal of a variety of materials such as substandard TNT, barrels of chemicals, oil, paint, scrap iron, and wood. This area was reportedly backfilled and covered, and operations continued moving eastward, raising the ground surface (before cap) to 15 feet above the original grade.



Source: *Jacobs Engineering Group Inc., March 2002. Final Feasibility Study for Site 16, Longhorn Army Ammunition Plant, Karnack, Texas*

Site Location Map
Site 16 Landfill, LHAAP
Karnack, Texas

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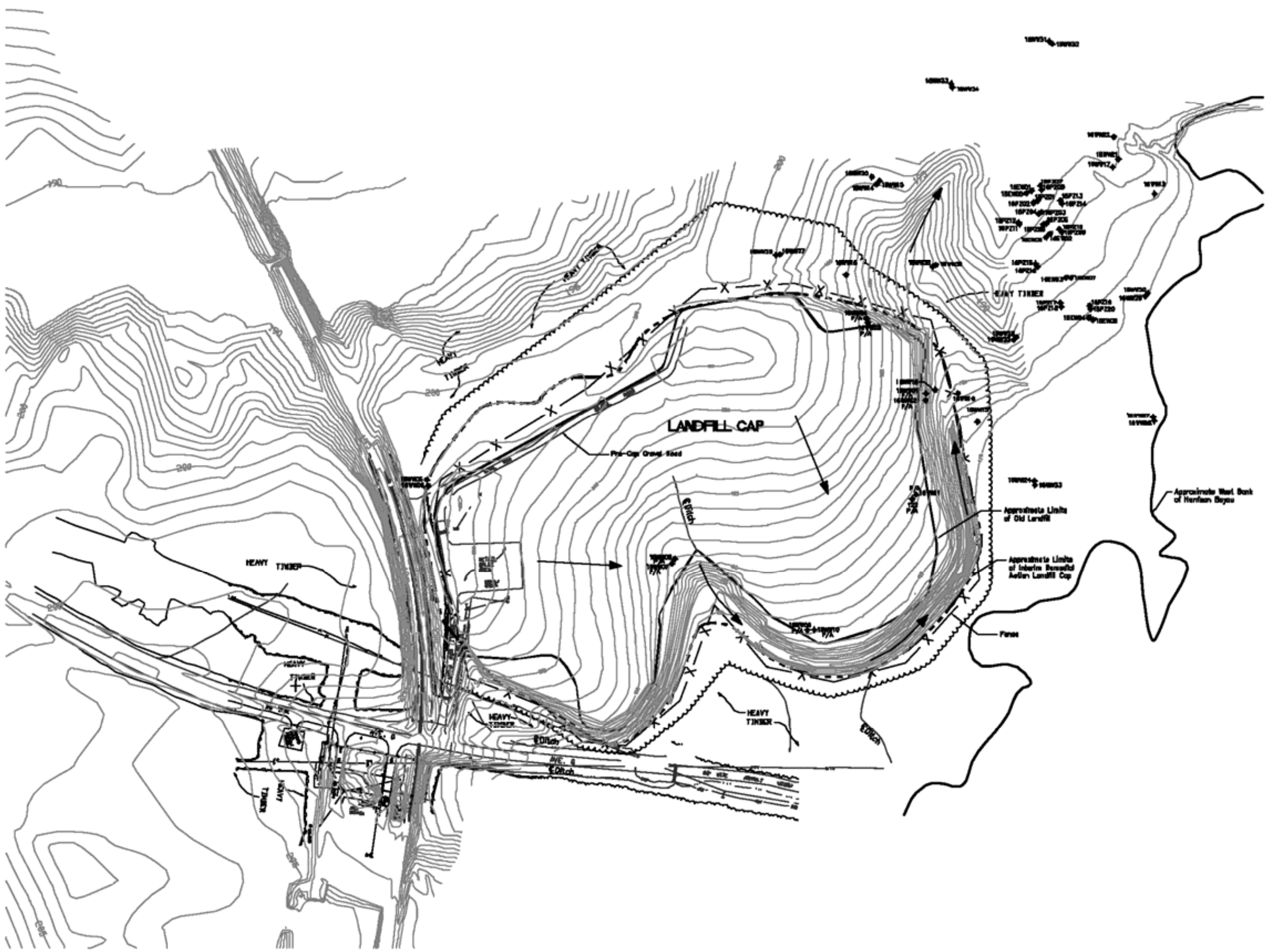
Figure 4-1



N

Legend

- Buildings
- Roads
- Shallow Monitoring Well
- Intermediate Monitoring Well
- Deep Monitoring Well
- Shallow Piezometer
- Intermediate Piezometer
- Shallow Extraction Well
- Intermediate Extraction Well
- P/A Plugged and Abandoned
- —X— Fence

0 200 400
Scale in Feet

Source: *Jacobs Engineering Group Inc., March 2002. Final Feasibility Study for Site 16, Longhorn Army Ammunition Plant, Karnack, Texas*

Site 16 Location
Site 16 Landfill, LHAAP
Karnack, Texas

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Figure **4-2**

Burn pits and waste storage were common at the site, but there is little documentation of these activities. It is thought that two rocket motor casings were burned and buried on the eastern side of the landfill. Site 16 was used for disposal of all types of solid and industrial waste until the 1980s when disposal activities were moved to Site 12, Landfill 12. The Site 16 landfill is no longer in use.

In August 1990, the installation was placed on the National Priorities List. A Federal Facility Agreement (FFA) among the USEPA, the Army, and the Texas Natural Resource Conservation Commission (TNRCC) became effective December 30, 1991.

Remedial actions conducted at Site 16 have included the installation of a groundwater extraction system and a multilayer cover. The groundwater extraction system was installed in 1996 and 1997 as a treatability study. The groundwater extracted from eight wells is piped to the Burning Ground 3 Groundwater Treatment Plant. The multilayer cap was installed at the landfill in 1998, completed as a result of an Interim Remedial Action Record of Decision signed in 1995.

4.2 SITE GEOLOGY/HYDROGEOLOGY

The surface soil at Site 16 is a very fine sandy loam. A silty clay loam is also found in the floodplain of Harrison Bayou where flooding occurs frequently. The subsurface geology at Site 16 consists primarily of a thin veneer of Quaternary alluvium mantling Tertiary age formations of the Wilcox and Midway Groups. Underlying these are Cretaceous age formations of the Navarro and Taylor Groups. The Wilcox Group, which constitutes a majority of the unconsolidated sediments underlying Site 16, consists of interbedded sands, silts, and clays. **Figure 4-3** summarizes the geology of the site.

The uppermost portion of the Wilcox Group generally consists of medium plastic sandy silt and clay ranging in thickness from 5 to 15 feet. The first water-bearing zone or shallow saturated sand zone varies in thickness from 9 to 18 feet and underlies the surficial sediment. A medium to highly plastic silty clay layer (semi-confining), 3–22 feet thick, underlies the sand zone. An intermediate sand zone, consisting of a fine to medium silty sand, lies 30–50 feet below ground surface (bgs). This intermediate zone contains fewer fines than the shallow sand zone and has a higher hydraulic conductivity. Beneath this intermediate sand zone is another silt to silty clay layer varying in thickness from 5 to 30 feet. A homogeneous silty, clayey, fine sand layer, approximately 150–230 feet thick, exists at the top of the Midway Formation. The Midway Formation is a thick clay layer containing some sand and is generally found 227–307 feet below ground surface (bgs).

Based on nearly 100 borings, monitoring wells, and geoprobe points, the subsurface hydrogeology at Site 16 can generally be characterized as consisting of three water-bearing sandy zones that are separated by semi-confining clay layers. However, there is considerable heterogeneity across the site as the sand layers vary in depth. The geologic logs from the eight

Geologic Formation	Sub-Units	Soil Type	Thickness (ft)	Zone	Well Located in the Zone	Hydraulic Conductivity Range (cm/sec)	Contaminants
Wilcox		Sandy Silt/Clay	5-15				
		Fine Silty Sand	9-18	Shallow Groundwater Zone	1, 3, 5, 7, 9, 12, 13, 14, 16, 22, 24, 26, 28, 30 32, 34, 36, 38, EW1, EW2, EW3, EW4	1.15×10^{-3} - 4.94×10^{-5} (Average 8.7×10^{-4})	VOCs, Perchlorate
		Silty Clay	3-22	Aquiclude			
		Fine-Medium Silty Sand	20	Intermediate Groundwater Zone	2, 4, 6, 8, 10, 11, 23, 25, 27, 29, 31, 33, 35, 37, EW5, EW6, EW7, EW8	3.97×10^{-2} - 5.93×10^{-4} (Average 1.5×10^{-3})	VOCs, Perchlorate
		Silty Clay	5-30	Aquiclude			
		Silty/Clayey Fine Sand	150-232	Upper Deep Groundwater Zone	19, 20, 21	1.91×10^{-5} - 1.47×10^{-5} (Average 1.7×10^{-5})	VOCs
				Lower Deep Groundwater Zone	15, 17, 18	5.04×10^{-4} - 3.39×10^{-4} (Average 4.2×10^{-4})	TCE
Midway		Clay		Aquitard			

VOCs - Volatile Organic Compounds

TCE - Trichloroethene

Source: *Jacobs Engineering Group Inc., March 2002. Final Feasibility Study for Site 16, Longhorn Army Ammunition Plant, Karnack, Texas*

Summary of Site Geology and Hydrogeology
Site 16 Landfill, LHAAP
Karnack, Texas

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Figure **4-3**

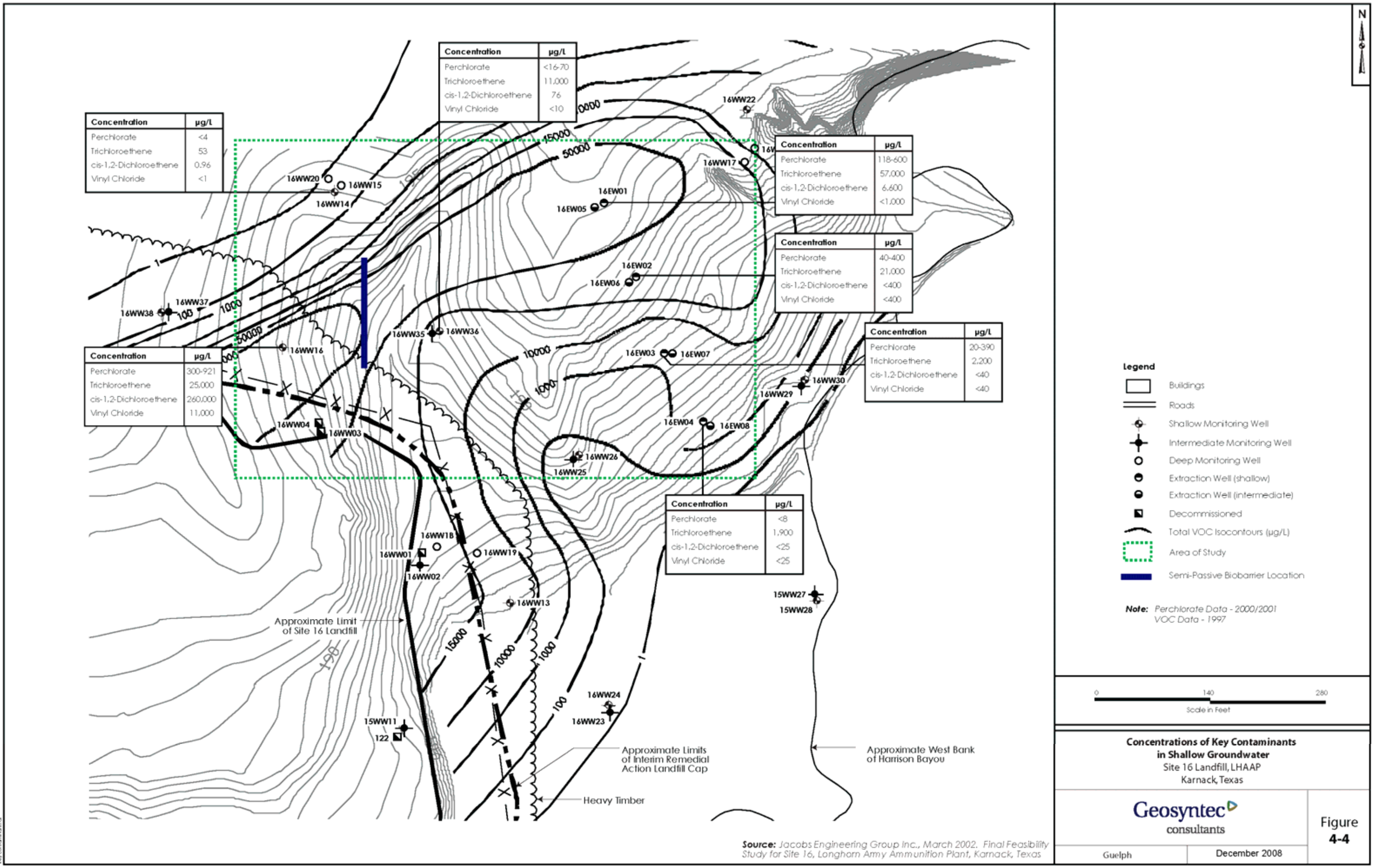
groundwater extraction wells installed to the northeast of the landfill illustrate the degree of heterogeneity as the wells have diverse yields with variable transmissivity and storativity.

Rising head slug tests were conducted and water level measurements were obtained for all Site 16 monitoring wells. The mean hydraulic conductivity for each zone is presented on Figure 4-3. The mean hydraulic conductivity value varies from 1.5 x 10^{-3} centimeters per second (cm/sec) in the shallow zone to 4.2 x 10^{-4} cm/sec in the deep zone. The average hydraulic gradient varies from 0.0027 foot/foot in the easterly direction in the deep zone to 0.0104 foot/foot in the northeasterly direction in the shallow zone. The groundwater velocity is estimated to vary from 0.31 feet/year in the deep zone to 37 feet/year in the shallow and intermediate zones.

4.3 CONTAMIANT DISTRIBUTION

Groundwater in the vicinity of the Site 16 landfill is impacted by perchlorate and several chlorinated VOC, most notably TCE, cis-1,2-DCE and VC. Perchlorate analyses were conducted on groundwater samples collected in May 2000, September 2000, and January 2001. Data from these sampling events are summarized for the shallow aquifer in the study area in Figure 4-4. The aerial extent of perchlorate and chlorinated solvents is similar in the shallow and intermediate aquifers; however, perchlorate is not present in the deeper water bearing zone beneath and downgradient of the landfill. Figure 4-3 also illustrates the vertical extent of perchlorate and VOC impacts in the shallow zone of the groundwater. February 2003 groundwater samples collected from wells 16WW16 and 16WW36 detected significantly lower VOC concentrations (5 mg/L total VOC) compared to detected in previous sampling and shown in Figure 4-4. It is unclear whether the differing concentrations are the result of temporal VOC declines or seasonal fluctuations.

Results of additional groundwater sampling conducted as part of the demonstration are presented in Section 6.


Concentration μg/L
Perchlorate <16-70
Trichloroethene 11,000
cis-1,2-Dichloroethene 76
Vinyl Chloride <10
Concentration μg/L
Perchlorate <4
Trichloroethene 53
cis-1,2-Dichloroethene 0.96
Vinyl Chloride <1
Concentration μg/L
Perchlorate 118-600
Trichloroethene 57,000
cis-1,2-Dichloroethene 6,600
Vinyl Chloride <1,000
Concentration μg/L
Perchlorate 40-400
Trichloroethene 21,000
cis-1,2-Dichloroethene <400
Vinyl Chloride <400
Concentration μg/L
Perchlorate 20-390
Trichloroethene 2,200
cis-1,2-Dichloroethene <40
Vinyl Chloride <40
Concentration μg/L
Perchlorate 300-921
Trichloroethene 25,000
cis-1,2-Dichloroethene 260,000
Vinyl Chloride 11,000
Concentration μg/L
Perchlorate <8
Trichloroethene 1,900
cis-1,2-Dichloroethene <25
Vinyl Chloride <25
16WW22
16WW17
16WW20
16WW15
16WW14
16EW01
16EW05
16EW02
16EW06
16WW37
16WW38
16WW35
16WW36
16WW16
16EW03
16EW07
16WW30
16WW29
16WW04
16WW03
16EW04
16EW08
16WW26
16WW25
16WW18
16WW01
16WW19
16WW02
16WW13
15WW27
15WW28
16WW24
16WW23
15WW11
122
Approximate Limit of Site 16 Landfill
Approximate Limits of Interim Remedial Action Landfill Cap
Heavy Timber
Approximate West Bank of Harrison Bayou
Legend
Buildings
Roads
Shallow Monitoring Well
Intermediate Monitoring Well
Deep Monitoring Well
Extraction Well (shallow)
Extraction Well (intermediate)
Decommissioned
Total VOC Isocontours (μg/L)
Area of Study
Semi-Passive Biobarrier Location
Note: Perchlorate Data - 2000/2001
VOC Data - 1997
N
0 140 280
Scale in Feet
Source: Jacobs Engineering Group Inc., March 2002. Final Feasibility Study for Site 16, Longhorn Army Ammunition Plant, Karnack, Texas
Concentrations of Key Contaminants
in Shallow Groundwater
Site 16 Landfill, LHAAP
Karnack, Texas
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Guelph
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Figure 4-4

5. DESIGN

This section describes the design and the results of the demonstration test. Section 5.1 presents a conceptual experimental design; Section 5.2 describes the baseline characterization that was conducted; Section 5.3 describes the results of a laboratory treatability study; Section 5.4 describes the design and layout of the technology components for the demonstration; Section 5.5 describes the field testing that was conducted; Section 5.6 describes the sampling methods; and Section 5.7 presents the results of the sampling conducted to monitor the field demonstration.

5.1 CONCEPTUAL EXPERIMENTAL DESIGN

The goal of this Dem/Val program is to demonstrate a semi-passive EISB approach that involved periodic delivery of electron donor to create a biologically active zone or biobarrier across a perchlorate plume, for the purposes of promoting perchlorate biodegradation and controlling plume migration.

In concept, the semi-passive biobarrier approach involved the use of alternating extraction and injection (recirculation) wells installed across a perchlorate plume. To add and mix the electron donor across the plume, groundwater was periodically extracted, amended with electron donor, and recharged to the aquifer to promote *In Situ* biodegradation of perchlorate and prevent migration of perchlorate beyond the biobarrier. The distance between the recirculation wells was 35 feet (versus much closer centers typically required for passive slow-release donor injection points). The time required to circulate the electron donors across the plume with the alternating extraction/injection wells was small (on the order of 2 to 3 weeks), whereas the time interval between injections was fairly large (i.e., 6 to 8 months). Once electron donor was delivered, recirculation was stopped, and the electron donor was allowed to migrate in groundwater to promote biodegradation of perchlorate. Biomass generated by each batch injection decayed over time and the organic compounds released by this decay helped extend the period between injections. Because the recirculation of groundwater was conducted for only short periods of time, the equipment used was simple and incorporated minimal automated controls and no storage tanks. Submersible pumps were installed in the extraction wells and were set to turn off if the water in the extraction wells dropped too low or if the water level in the injection well rose too high. Electron donor was poured directly into the injection wells and into intermediate injection points manually to minimize the equipment required.

5.2 BASELINE CHARACTERIZATION

Groundwater samples were collected and analyzed to determine baseline conditions and the electron donor requirements to degrade perchlorate. One set of baseline samples was collected in June 2003. A second set of baseline samples was collected in March 2004 with the groundwater recirculation system operating, but prior to addition of electron donor. Analyses included:

- Field parameters (dissolved oxygen (do), oxidation reduction potential (ORP), pH, conductivity and temperature);
- Perchlorate and associated degradation products (e.g., chlorate, chloride);

- Volatile organic compounds (VOC);
- Dissolved hydrocarbon gases (DHG; methane, ethane, ethene);
- Anions (bromide, nitrate, nitrite, phosphate and sulfate);
- Metals (total and dissolved);
- Volatile fatty acids (acetate, formate, propionate);
- Microbial Characterization; and
- Metabolic products (e.g., sulfide).

Samples were collected by Complete Environmental Solutions (CES), the local on-site environmental contractor (under subcontract to Geosyntec), following sampling protocols established for the site in Section 3.6.7 and Appendix A of the Demonstration Plan. Analyses were conducted by BioInsite, LLC or by Severn Trent Laboratories (STL) located in Houston, Texas. Details of the analytical methods, container size and type, preservation method, and sample holding times are presented in the Demonstration Plan.

5.3 LABORATORY TREATABILITY STUDY RESULTS

A laboratory treatability study was conducted to evaluate the potential to degrade perchlorate and chlorinated solvents, primarily TCE and cis-1,2-dichloroethene (cis-DCE), present in the groundwater. The results of the study are presented in Appendix B.

The study demonstrated that:

- The site groundwater and soil did not contain adequate electron donors to promote rapid reductive dechlorination of TCE but would degrade some perchlorate.
- The addition of soluble electron donor (a mixture of methanol, ethanol, acetate and lactate or MEAL) did not result in any TCE or cis-DCE dechlorination over the incubation period. This suggests that these electron donors alone may not be sufficient to promote indigenous Dehalococcoides to degrade chlorinated ethenes (i.e., TCE, cis-DCE, and vinyl chloride) that may be present at the site or a greater acclimation period is needed.
- Complete and rapid dechlorination of TCE via cis-DCE and vinyl chloride to ethene was observed in the bioaugmented microcosm amended with soluble electron donor (MEAL) and the natural, non-pathogenic microbial consortium KB-1.
- Some degradation of perchlorate was observed in the absence of amendment, but addition of soluble electron donor resulted in more rapid degradation of perchlorate.

5.4 DESIGN AND LAYOUT OF TECHNOLOGY COMPONENTS

The semi-passive electron donor system included a series of five recirculation wells installed in a line perpendicular to the direction of groundwater flow. The wells were designed to be used as extraction or injection wells, as required, to distribute electron donor across the treatment area. The target depth interval for treatment was the Shallow Groundwater Zone, as shown in Figure 4-3. Figure 5-1 shows the location of the recirculation wells, intermediate injection wells, performance monitoring wells and soil borings in the vicinity of the demonstration area. Table 5-1 presents the construction details for the wells that were installed.

Pump tests were conducted at each of the recirculation wells to determine the sustainable groundwater flow and to refine the design of the electron donor delivery system. The results of the testing indicated that the sustainable flowrates were lower than anticipated based on historic data. Additional recirculation wells (16EW12B and 16EW14B) with deeper and longer (15 ft) well screens were installed in December 2003 adjacent to wells 16EW12 and 16EW14 to allow for the extraction of groundwater at higher flowrates. In addition, intermediate injections wells (IW-1 through IW-8) were installed, between the recirculation wells, after groundwater modeling (see Section 5.4) suggested that the period of time required to distribute electron donor across the entire biobarrier would be longer than originally anticipated.

Figures 5-2, 5-3, 5-4, 5-5, and 5-6 present geological cross sections for the wells and borings in the demonstration area. Borehole logs and well construction details are included in Appendix C. The cross section along the line of the injection/extraction wells (Figure 5-2) shows interbedded layers of silty sand, sandy silt, clayey silt, silty clay, and clay consistent with the interbedded sands, silts and clays of the Wilcox Group found at the Site. The top of the recirculation well screens are located at approximately the depth of the water table (~14 to 17 feet bgs). Wells screens for 16EW15, 16EW13 and 16EW11 are each 10 feet in length, while the screens for 16EW14B and 16EW12B are 15 feet long and extend to a deeper elevation. The well screens generally intersect a shallow silty sand layer and a portion of a deeper silty sand layer that is separated from the shallow silty sand layer by interbedded silt and clay layers. As shown in Figures 5-3, 5-4, 5-5 and 5-6, the geology shows a very high degree of variability and heterogeneity, far greater than understood (based on available data) during Site selection. In general, the monitoring wells with 10-foot long screens are screened across both silty sand layers. At the locations where shallow monitoring wells with 5-foot screens were installed they intersect the shallow silty sand layer. At the locations where deep monitoring wells with 5-foot screens are installed they intersect the top of the deeper silty sand layer.

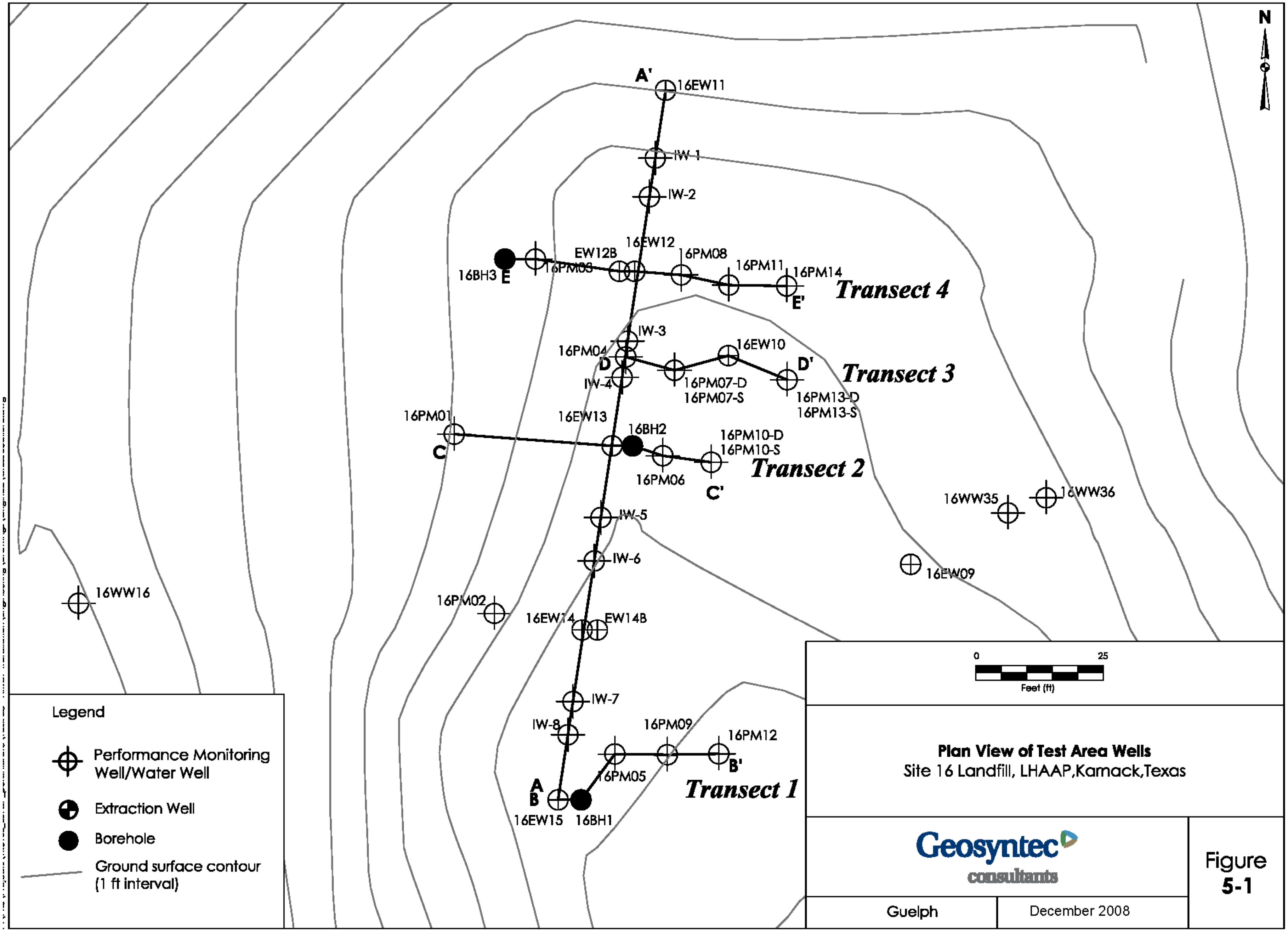
TABLE 5-1: WELL CONSTRUCTION DETAILS
Site 16 Landfill, LHAAP, Karnack, Texas

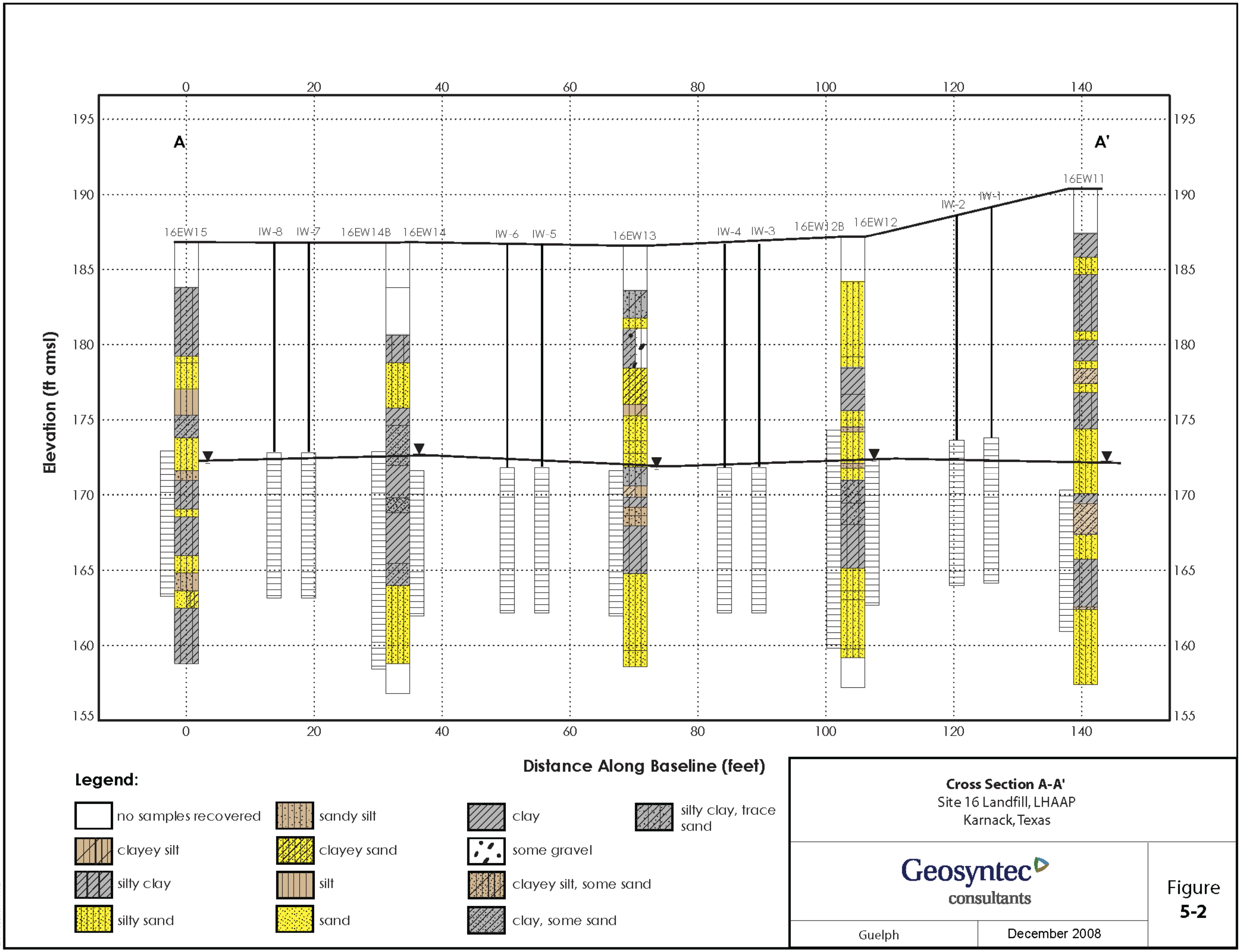
Well ID	Installation Date	Drilling Method*	Total Depth (ft bgs)	Top of Screen (ft bgs)	Bottom of Screen (ft bgs)	Borehole Diameter (inches)	PVC Casing Diameter (inches)	Ground Surface (ft amsl)	Top PVC Casing (ft amsl)	Coordinates (Northings)	Coordinates (Eastings)
16PM01	24-Jun-03	HSA	28	15.1	24.8	8.5	2	187.5	190.50	6,953,672.6	3,313,969.2
16PM02	24-Jun-03	HSA	28	15.1	24.8	8.5	2	188.0	191.08	6,953,637.4	3,313,977.1
16PM03	25-Jun-03	HSA	25	15.0	24.5	8.5	2	187.5	190.44	6,953,706.8	3,313,985.1
16PM04	23-Jun-03	HSA	28	15.1	24.8	8.5	2	187.0	190.39	6,953,687.7	3,314,002.8
16PM05	23-Jun-03	HSA	28	14.0	23.6	8.5	2	185.9	188.95	6,953,609.9	3,314,000.7
16PM06	24-Jun-03	HSA	28	14.9	24.6	8.5	2	186.4	189.57	6,953,668.3	3,314,010.1
16PM07S	23-Jun-03	HSA	28	12.8	17.3	8.5	1	187.2	190.39	6,953,685.1	3,314,012.4
16PM07D	23-Jun-03	HSA	28	21.3	25.8	8.5	1	187.2	190.41	6,953,684.1	3,314,012.4
16PM08	25-Jun-03	HSA	28	15.2	24.8	8.5	2	187.6	190.96	6,953,703.7	3,314,013.7
16PM09	24-Jun-03	HSA	25	14.1	23.8	8.5	2	185.5	188.26	6,953,609.7	3,314,011.0
16PM10S	24-Jun-03	HSA	28	12.8	17.3	8.5	1	186.3	189.63	6,953,667.1	3,314,019.6
16PM10D	24-Jun-03	HSA	28	21.3	25.8	8.5	1	186.3	189.64	6,953,667.1	3,314,019.6
16PM11	25-Jun-03	HSA	28	15.2	24.8	8.5	2	187.9	190.91	6,953,701.7	3,314,023.7
16PM12	24-Jun-03	HSA	25	14.1	23.8	8.5	2	185.2	188.09	6,953,609.9	3,314,021.1
16PM13S	25-Jun-03	HSA	28	12.8	17.3	8.5	1	186.9	189.80	6,953,683.2	3,314,034.5
16PM13D	25-Jun-03	HSA	28	21.3	25.8	8.5	1	186.9	189.80	6,953,683.2	3,314,034.5
16PM14	25-Jun-03	HSA	28	15.2	24.8	8.5	2	188.2	191.18	6,953,701.6	3,314,034.4
16EW09	25-Mar-03	HSA	28	16.1	25.5	10.3	4	187.4	190.37	6,953,647.1	3,314,058.7
16EW10	25-Mar-03	HSA	33	18.1	27.5	10.3	4	187.7	190.48	6,953,687.9	3,314,023.0
16EW11	26-Mar-03	HSA	33	20.1	29.5	10.3	4	190.4	193.43	6,953,739.9	3,314,010.7
16EW12	23-Jun-03	HSA	28	15.0	24.6	10.0	4	187.2	190.43	6,953,704.4	3,314,004.6
16EW12B	08-Dec-03	HSA	28	13.0	28.0	10.0	4	--	--	- -	- -
16EW13	24-Jun-03	HSA	28	15.0	24.6	10.0	4	186.6	189.89	6,953,670.3	3,314,000.2
16EW14	24-Jun-03	HSA	26	15.1	24.5	10.0	4	186.8	189.77	6,953,634.2	3,313,994.3
16EW14B	08-Dec-03	HSA	30	14.0	29.0	10.0	4	--	--	- -	- -
16EW15	23-Jun-03	HSA	28	13.9	23.5	10.0	4	186.8	189.82	6,953,600.9	3,313,989.6
16IW01	02-Sep-03	HSA	25	15.0	25.0	8.0	2	--	--	6,953,726.6	3,314,008.6
16IW02	02-Sep-03	HSA	25	15.0	25.0	8.0	2	--	--	6,953,719.0	3,314,007.5
16IW03	02-Sep-03	HSA	25	15.0	25.0	8.0	2	--	--	6,953,690.8	3,314,003.2
16IW04	03-Sep-03	HSA	25	15.0	25.0	8.0	2	--	--	6,953,683.7	3,314,002.1
16IW05	02-Sep-03	HSA	25	15.0	25.0	8.0	2	--	--	6,953,656.2	3,313,998.0
16IW06	02-Sep-03	HSA	25	15.0	25.0	8.0	2	--	--	6,953,647.8	3,313,996.7
16IW07	03-Sep-03	HSA	24	14.0	24.0	8.0	2	--	--	6,953,620.2	3,313,992.5
16IW08	03-Sep-03	HSA	24	14.0	24.0	8.0	2	--	--	6,953,613.6	3,313,991.5

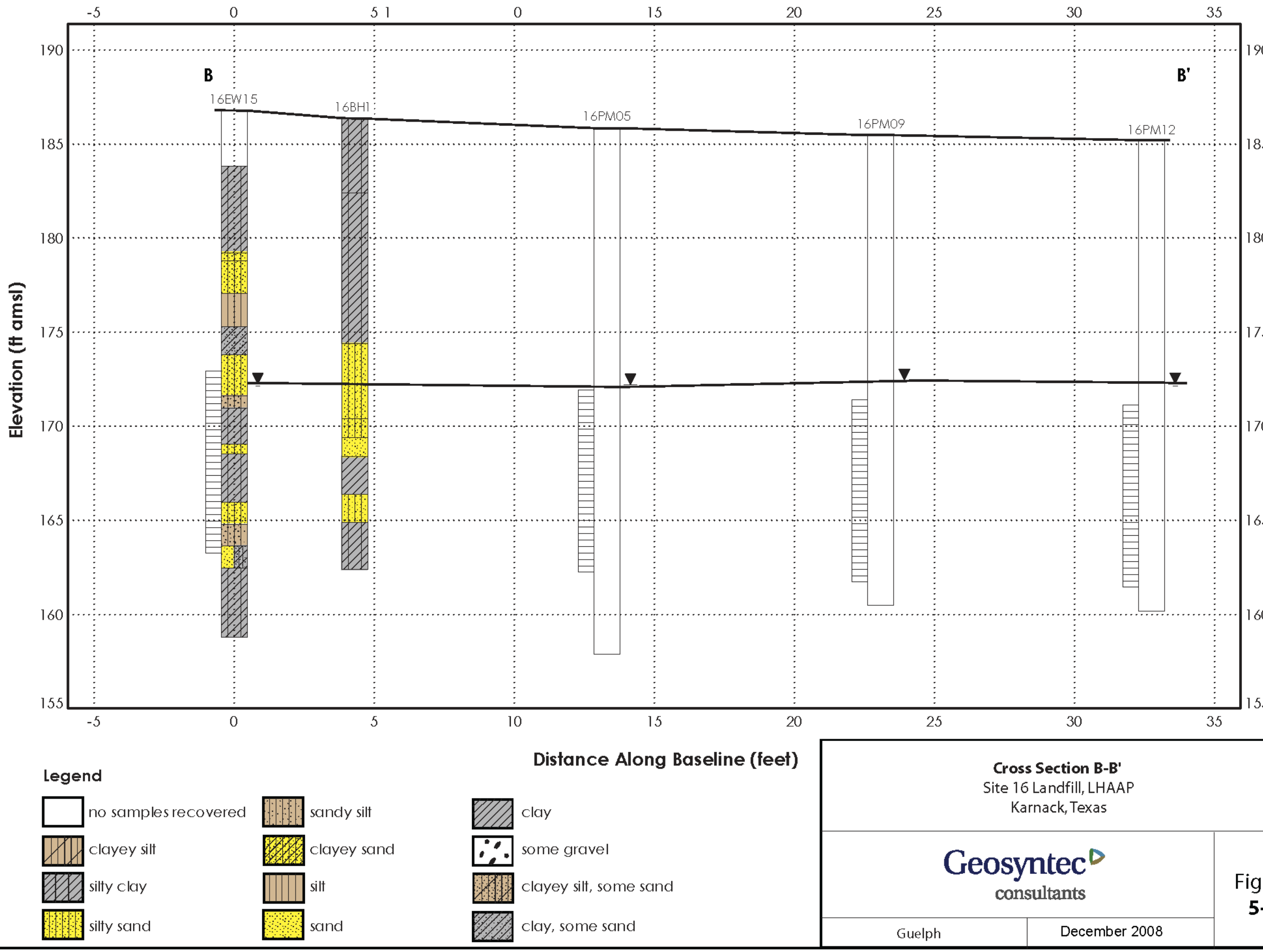
Notes:

HSA - Hollow Stem Augers
* Drilling conducted by ETTL Drilling Services
-- not available

ft - feet
amsl - above mean sea level
bgs - below ground surface


N
A'
16EW11
IW-1
IW-2
16EW12
EW12B
16PM08
16PM03
16BH3
E
16PM11
16PM14
E'
Transcept 4
IW-3
16EW10
16PM04
D
D'
Transect 3
IW-4
16PM07-D
16PM07-S
16PM13-D
16PM13-S
16PM01
16EW13
16BH2
16PM10-D
16PM10-S
C
Transect 2
16PM06
C'
16WW35
16WW36
IW-5
IW-6
16EW09
16WW16
16PM02
16EW14
EW14B
IW-7
IW-8
16PM09
16PM12
B'
16PM05
A
B
Transect 1
16EW15
16BH1
Legend
Performance Monitoring Well/Water Well
Extraction Well
Borehole
Ground surface contour (1 ft interval)
0
25
Feet (ft)
Plan View of Test Area Wells
Site 16 Landfill, LHAAP,Karnack,Texas
Geosyntec consultants
Figure 5-1
Guelph
December 2008


A
A'
16EW15
IW-8
IW-7
16EW14B
16EW14
IW-6
IW-5
16EW13
IW-4
IW-3
16EW12B
16EW12
IW-2
IW-1
16EW11
Elevation (ft amsl)
Distance Along Baseline (feet)
Legend:
no samples recovered
clayey silt
silty clay
silty sand
sandy silt
clayey sand
silt
sand
clay
some gravel
clayey silt, some sand
clay, some sand
silty clay, trace sand
Cross Section A-A'
Site 16 Landfill, LHAAP
Karnack, Texas
Geosyntec
consultants
Guelph
December 2008
Figure
5-2



Cross Section B-B'
Site 16 Landfill, LHAAP
Karnack, Texas

Geosyntec consultants

Figure **5-3**

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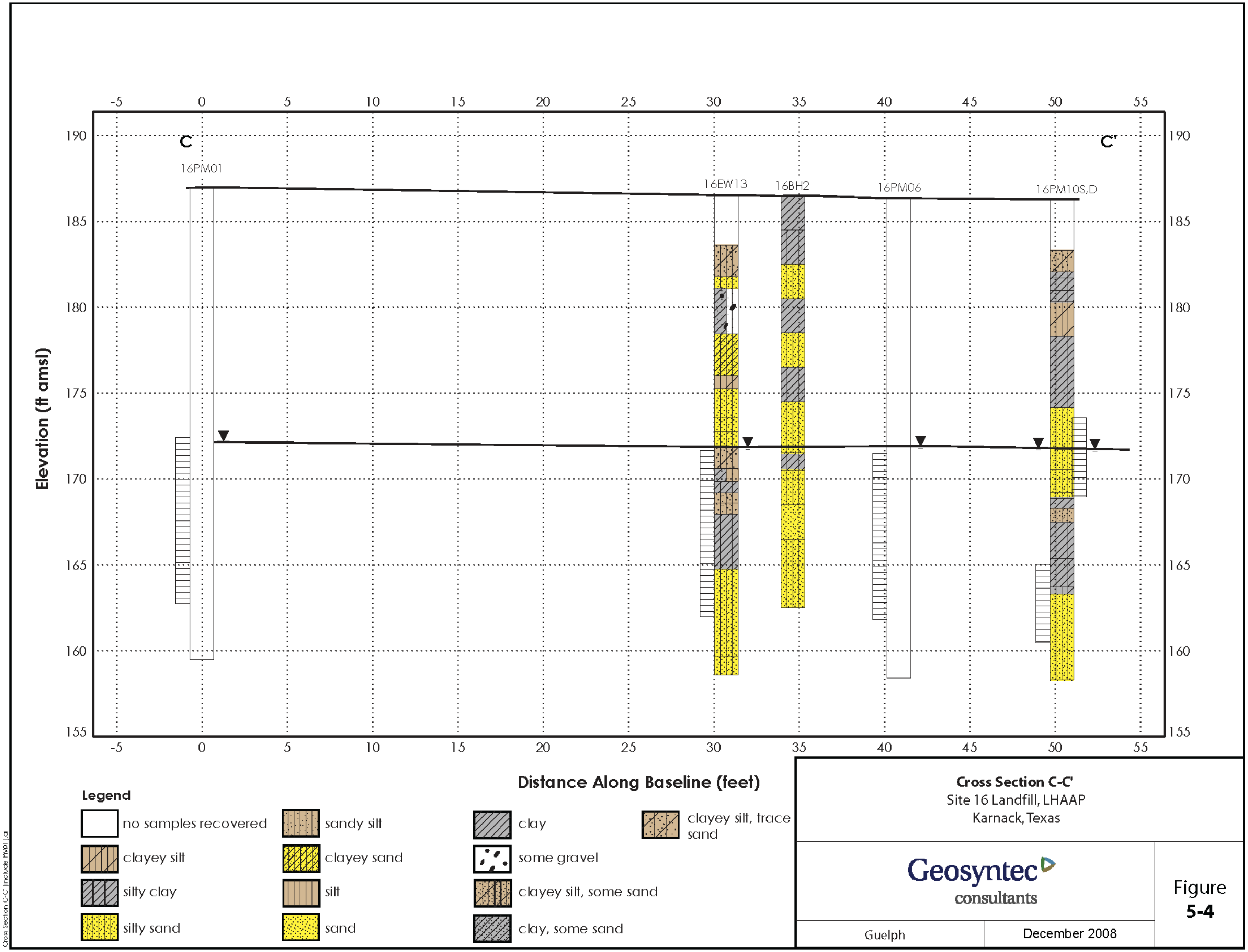
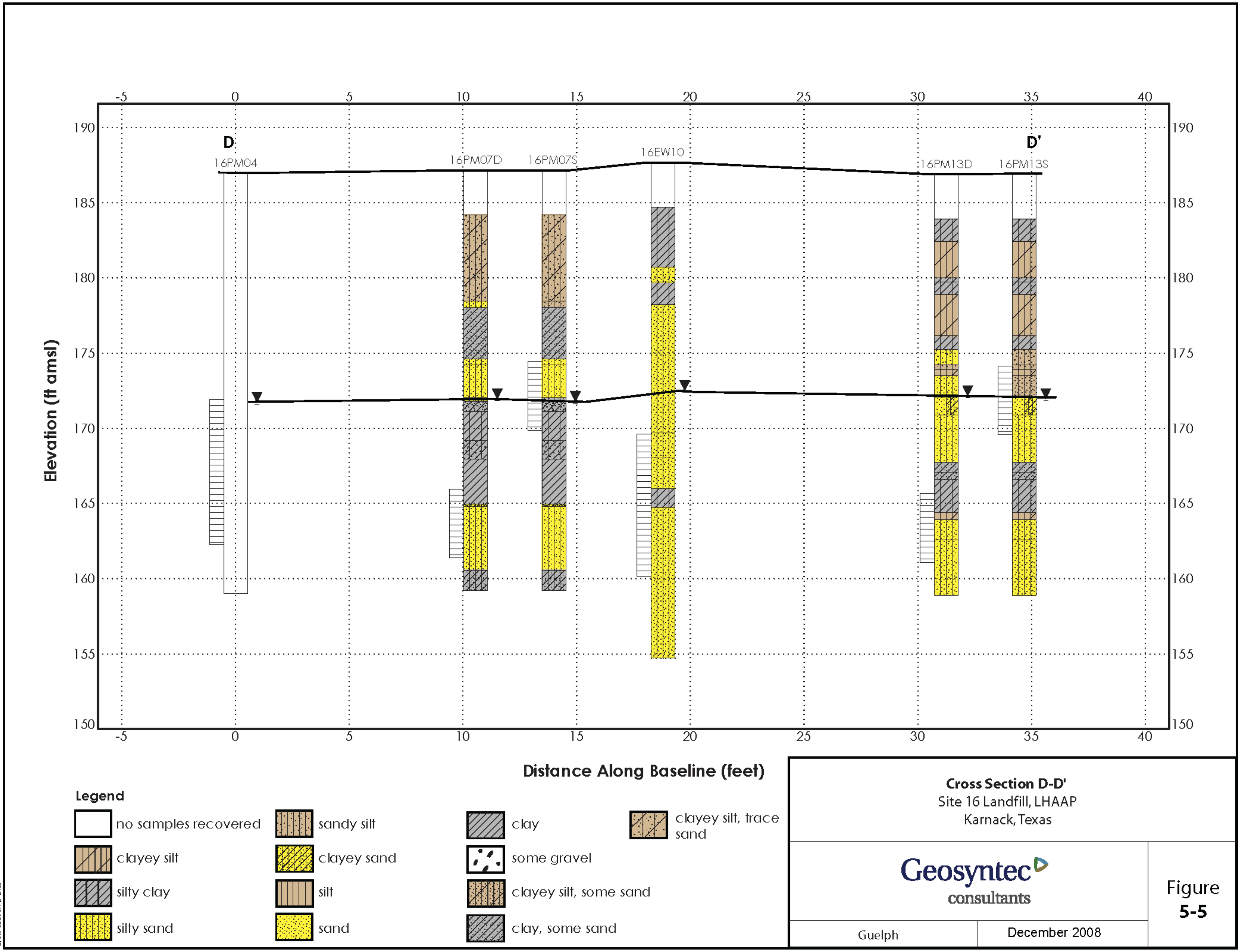
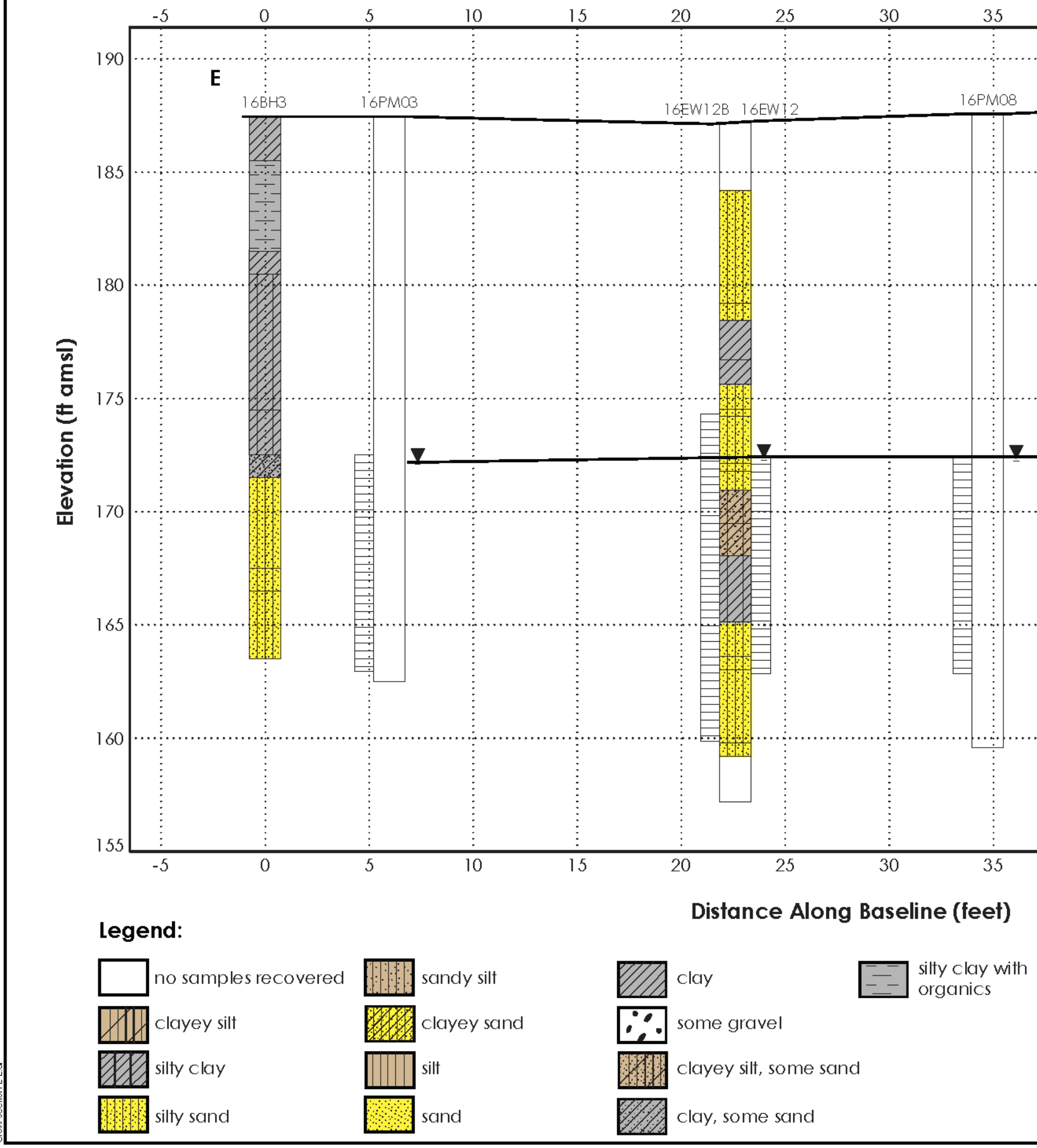

C
C'
16PM01
16EW13
16BH2
16PM06
16PM10S,D
Elevation (ft amsl)
190
185
180
175
170
165
160
155
-5
0
5
10
15
20
25
30
35
40
45
50
55
Distance Along Baseline (feet)
Legend
no samples recovered
sandy silt
clay
clayey silt, trace sand
clayey silt
clayey sand
some gravel
silty clay
silt
clayey silt, some sand
silty sand
sand
clay, some sand
Cross Section C-C'
Site 16 Landfill, LHAAP
Karnack, Texas
Geosyntec
consultants
Figure
5-4
Guelph
December 2008


D
D'
16PM04
16PM07D
16PM07S
16EW10
16PM13D
16PM13S
Elevation (ft amsl)
Distance Along Baseline (feet)
Legend
no samples recovered
clayey silt
silty clay
silty sand
sandy silt
clayey sand
silt
sand
clay
some gravel
clayey silt, some sand
clay, some sand
clayey silt, trace sand
Cross Section D-D'
Site 16 Landfill, LHAAP
Karnack, Texas
Geosyntec consultants
Figure 5-5
Guelph
December 2008



Cross Section E-E'
Site 16 Landfill, LHAAP
Karnack, Texas

Geosyntec consultants

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Figure **5-6**

The groundwater recirculation system included two extraction wells, flow meters and piping to split the flow from the points of extraction to three injection wells. The extraction wells were set to pump water at the maximum sustainable yield of about 1 to 2 gpm. These extraction rates were much lower than initially contemplated for the demonstration, based on available hydraulic data for the Site which suggested that extraction rates several times higher could be obtained. Figure 5.7 and Figure 5.8 show photographs of the system layout, extraction well piping and operators adding electron donor to the system.

Groundwater Modeling

Hydraulic information from the pump testing (step-drawdown and constant discharge) was used to develop a simplified numerical groundwater flow and transport model (using VisualMODFLOW). The model allowed for a variety of operating scenarios (extraction flowrates and configuration of recirculation wells) to be simulated. Additional information on the groundwater model used is presented in Appendix D.

Figure 5-9 shows the output of the groundwater model with the maximum groundwater extraction flowrate for each the two wells used initially for groundwater extraction (16EW14B and 16EW12B). This pumping scenario was used during the first and second batch injections of electron donor in April and December 2004. The model shows the groundwater flow lines from injection to extraction wells and the arrows indicate the distance traveled by groundwater in one month. For the purpose of this analysis, the biobarrier has been divided into four segments. In Segment 1, groundwater flows north from 16EW15 to 16EW14B; in Segment 2 groundwater flows south from 16EW13 to 16EW14B; in Segment 3 groundwater flows north from 16EW13 to 16EW12B; and in Segment 4 groundwater flows south from 16EW11 to 16EW12B. The model shows a high density of flow lines between extraction and injection wells in Segment 1, Segment 2, and Segment 4. A lower density of flowlines is seen in Segment 3. The travel time for groundwater between injection and extraction wells in Segments 1, 2 and 4 is approximately one to two months and two to three months in Segment 3. The lower density of flowlines and longer travel time in Segment 3 results from the diversion of some portion of the groundwater injected into 16EW13 to the south, towards 16EW12B which is able to operate at a higher extraction rate (~1.7 gpm) than 16EW14B (~1.0 gpm).

Figure 5-10 shows the output from the groundwater model with the groundwater recirculation pattern used during the third amendment cycle in November and December 2005. The groundwater recirculation pattern was modified during the third amendment cycle to provide higher quantities of electron donor to Segment 3 of the biobarrier which appeared to have received less than the target dosage of electron donor during the previous amendments. Groundwater was extracted from EW-14B at a rate of 1.7 gpm and the entire flow was injected into EW-12B. The model shows the groundwater flow lines from injection to extraction wells and the squares indicate the distance traveled by groundwater over a period of one month. In Segment 1, groundwater is drawn to the north from 16EW15 to 16EW14B; in Segment 2 groundwater flows south to 16EW14B; in Segment 3 groundwater flows south from 16EW12B;

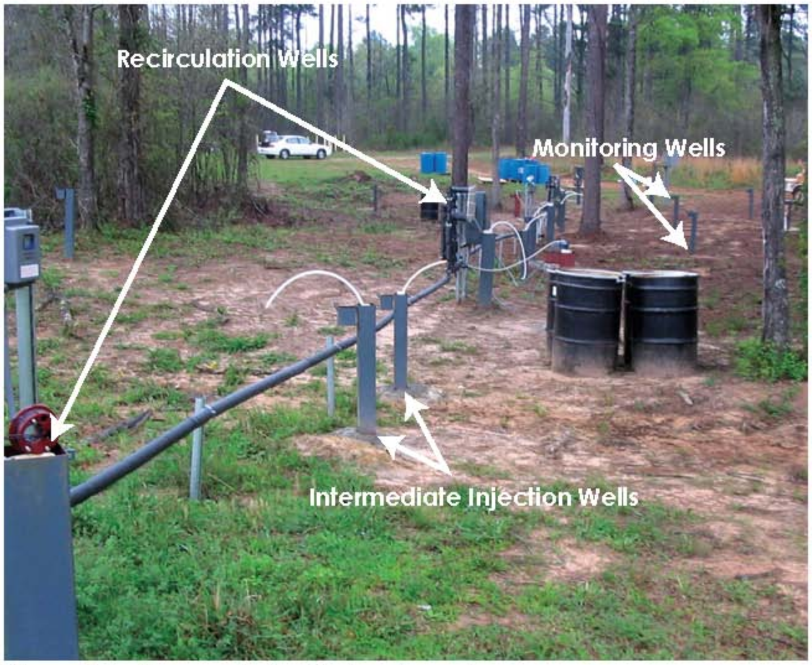

Figure 5-7a: Demonstration System Layout

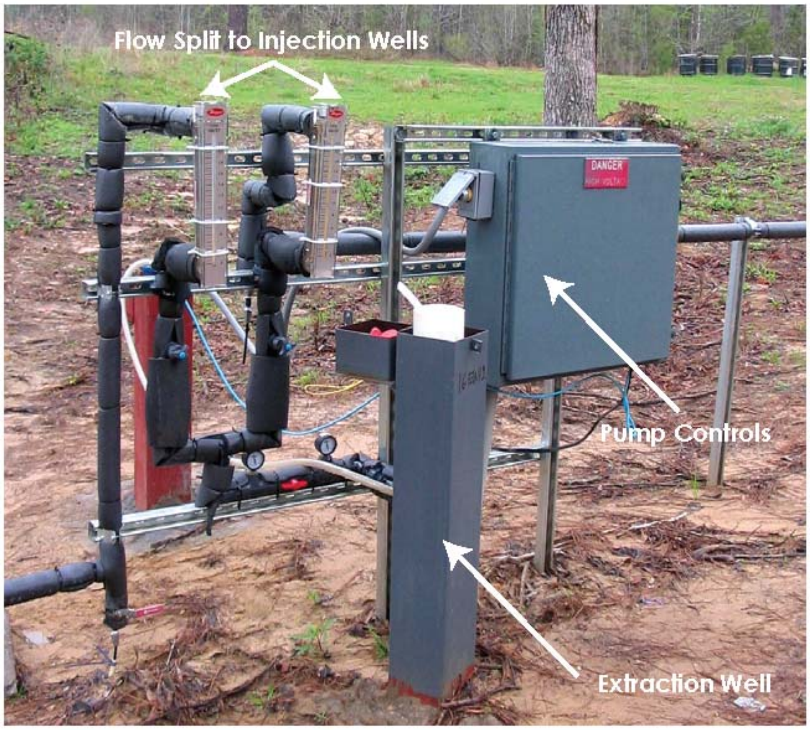

Figure 5-7b: Extraction Well Piping Configuration

Demonstration System Layout and Extraction Well Piping Site 16 Landfill, LHAAP Karnack, Texas		
Geosyntec consultants		Figure **5-7**
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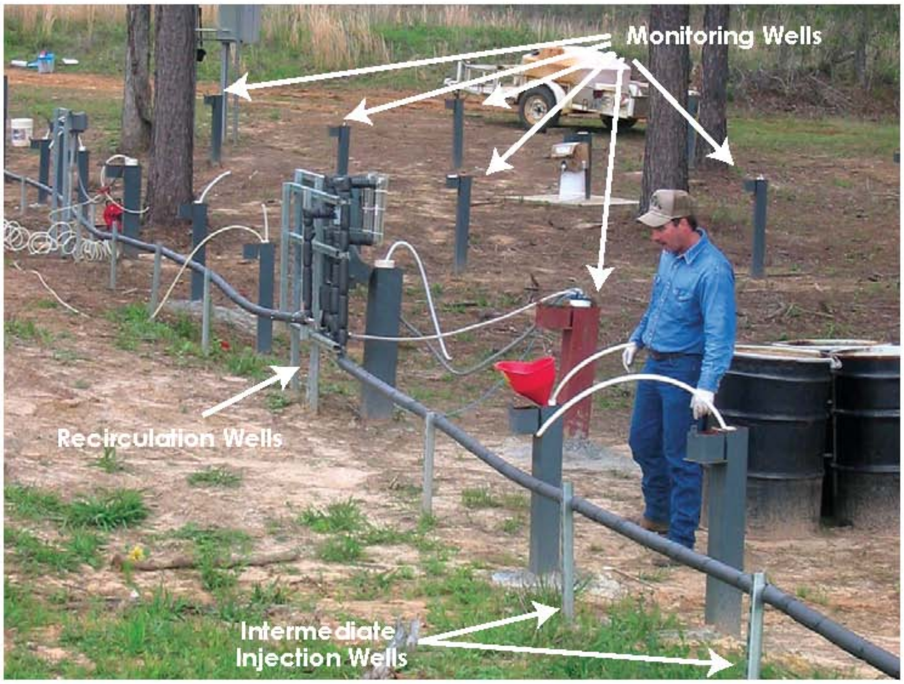
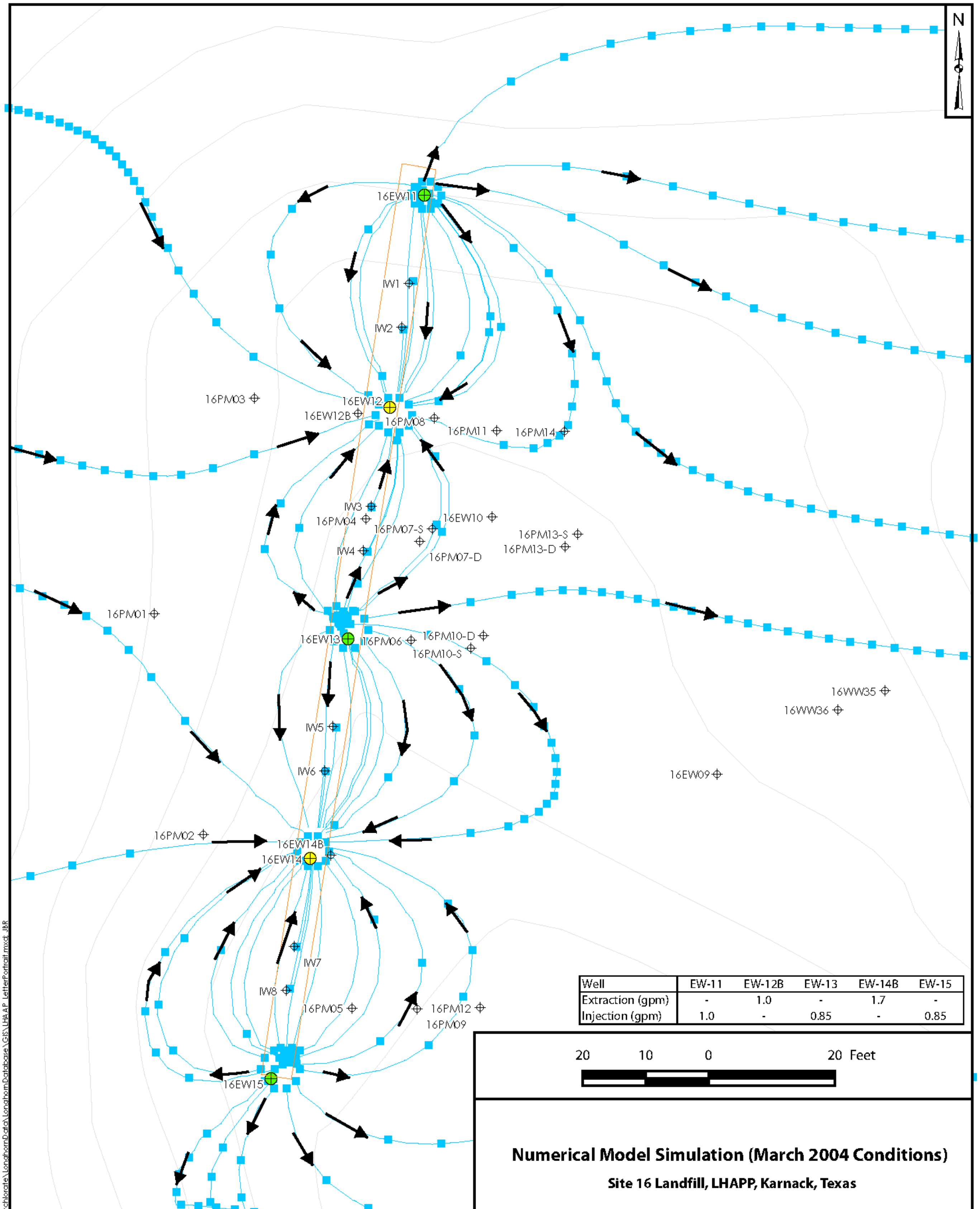


Figure 5-8a: Preparation for Electron Donor Addition

Figure 5-8b: Electron Donor Addition

Electron Donor Addition Site 16 Landfill, LHAAP Karnack, Texas		
Geosyntec consultants		Figure **5-8**
Guelph	December 2008	



Well	EW-11	EW-12B	EW-13	EW-14B	EW-15
Extraction (gpm)	-	1.0	-	1.7	-
Injection (gpm)	1.0	-	0.85	-	0.85

Numerical Model Simulation (March 2004 Conditions)

Site 16 Landfill, LHAPP, Karnack, Texas

Particle track	Monitoring Well
1-month travel marker	Extraction Well
Groundwater Flow Direction	Injection Well

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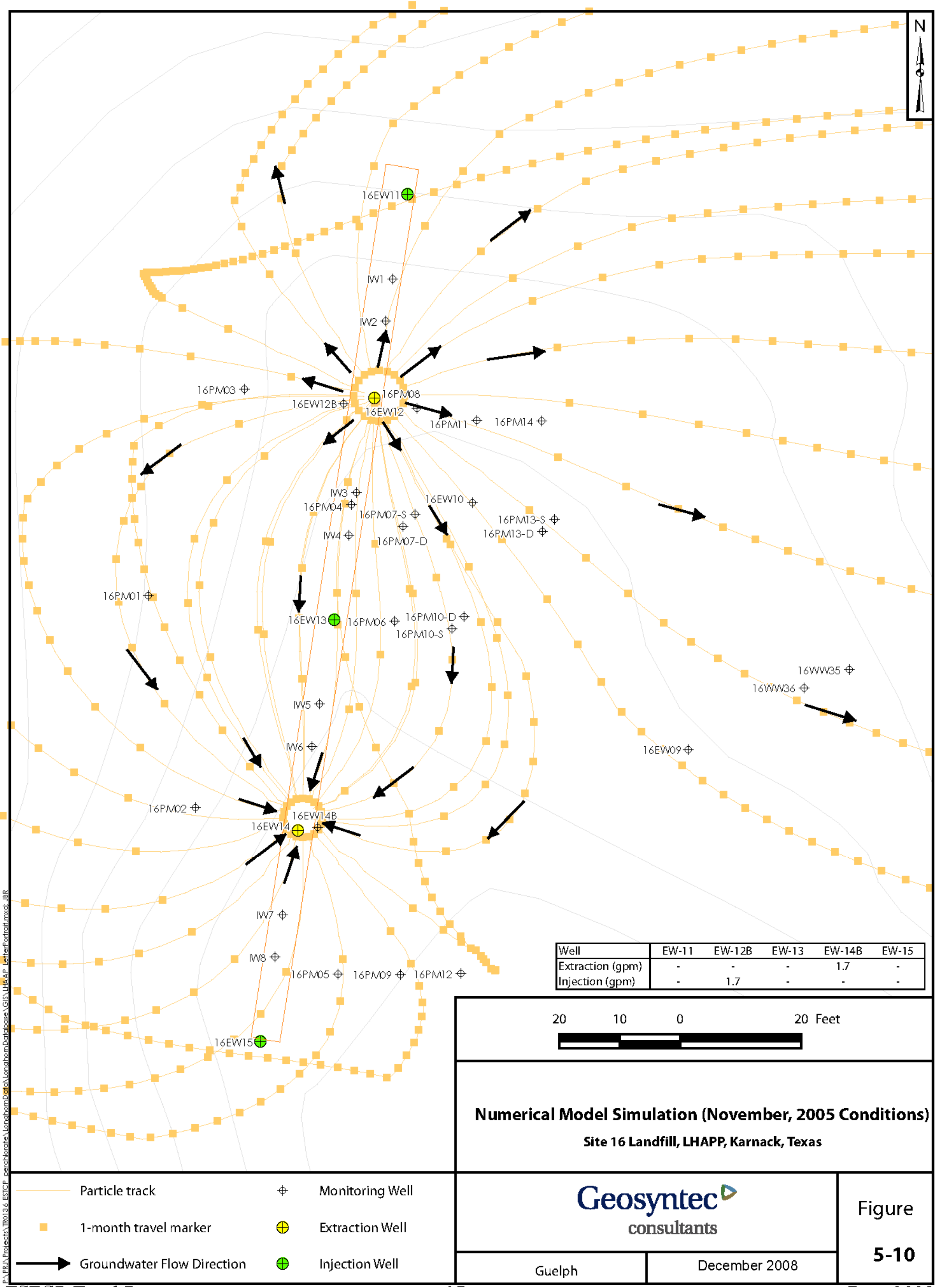
December 2008

Figure 5-9

P:\PRJ\Projects\TR0136 ESTCP perchlorate\LonghornData\LonghornDatabase\GIS\LHAAP LetterPortrait.mxd; JBR


N
16EW11
IW1
IW2
16PM03
16EW12B
16PM08
16EW12
16PM11
16PM14
IW3
16PM04
16PM07-S
16EW10
16PM13-S
16PM13-D
IW4
16PM07-D
16PM01
16EW13
16PM06
16PM10-D
16PM10-S
16WW35
16WW36
IW5
IW6
16EW09
16PM02
16EW14B
16EW14
IW7
IW8
16PM05
16PM09
16PM12
16EW15
Well | EW-11 | EW-12B | EW-13 | EW-14B | EW-15
Extraction (gpm) | - | - | - | 1.7 | -
Injection (gpm) | - | 1.7 | - | - | -
20 10 0 20 Feet
Numerical Model Simulation (November, 2005 Conditions)
Site 16 Landfill, LHAPP, Karnack, Texas
Particle track
1-month travel marker
Groundwater Flow Direction
Monitoring Well
Extraction Well
Injection Well
Geosyntec consultants
Guelph
December 2008
Figure
5-10

and in Segment 4 groundwater flows north from 16EW12B. The model shows a high density of flow lines in all segments and the travel time between recirculation wells, a distance of 35 feet, in each of the Segments is approximately one to two months.

5.5 FIELD TESTING

Table 5-2 presents a summary of the operation and monitoring of the demonstration system from the initiation of the tracer test in February 2004 to the completion of monitoring in June 2006. The activities conducted during the tracer test, electron donor amendment and monitoring phases are described in the following subsections.

5.5.1 Tracer Testing

Tracer testing was conducted in February to April 2004 and in November and December 2005 to:

- confirm breakthrough of amended water from the injection wells to the extraction wells during the active recirculation phase, and to determine when lateral coverage was achieved across the entire biobarrier; and

- evaluate flow patterns downgradient of the biobarrier.

During the first tracer test, groundwater recirculation and tracer injection began on February 11, 2004. Groundwater was extracted from 16EW12B and 16EW14B at rates of 1.0 gpm and 1.7 gpm respectively. Groundwater was injected into 16EW11, 16EW13 and 16EW15 at rates of 1.0 gallon per minute (gpm), 0.85 gpm and 0.85 gpm respectively. Iodide was added to 16EW13 on a continuous basis from February 11 to February 17, 2004 to produce a concentration of 500 milligrams per Liter (mg/L) in the injected water. Bromide was added to 16EW11 and 16EW15 over the same period of time to produce a concentration of 500 mg/L in the water injected in to these two well. The concentrations of iodide and bromide were measured in wells in the demonstration area until April 7, 2004.

During the second tracer test, groundwater recirculation system started on October 21, 2005 and tracer injection was initiated on November 7, 2005. Groundwater was extracted from 16EW14B at a rate of 1.7 gpm and injected into 16EW12B at rate of 1.7 gpm. Bromide was added to 16EW14B on a continuous basis from November 7 to November 10, 2005 to produce a concentration of 800 mg/L in the injected water. The concentrations of bromide were measured in wells in the demonstration area until December 19, 2005.

5.5.2 Electron Donor Amendment and System Monitoring

The initial dose of electron donor was calculated based on the amount required to reduce do, nitrate, and perchlorate in the groundwater, moving into the biobarrier for a period of eight months. A safety factor of 28 was applied to the dosage calculation to account for electron donor

TABLE 5-2: SUMMARY OF SYSTEM OPERATION AND MONITORING
Site 16 Landfill, LHAAP, Karnack, Texas

Date	Activity or Event			
	Groundwater Recirculation	**Tracer Test**	**Electron Donor Addition**	**Groundwater Monitoring**
11-Feb-04	Groundwater recirculation initiated	Tracer addition initiated		
11-Feb-04		Tracer monitoring initiated		
17-Feb-04		Tracer addition ended		
23-Mar-04				Groundwater monitoring
25-Mar-04			Electron donor addition initiated	
6-Apr-04				Groundwater monitoring
7-Apr-04		Tracer monitoring ended		
14-Apr-04	Groundwater recirculation ended		Electron donor addition ended	
20-Apr-04				Groundwater monitoring
4-May-04				Groundwater monitoring
18-May-04				Groundwater monitoring
2-Jun-04				Groundwater monitoring
16-Jun-04				Groundwater monitoring
7-Jul-04				Groundwater monitoring
4-Aug-04				Groundwater monitoring
28-Sep-04				Groundwater monitoring
1-Dec-04				Groundwater monitoring
3-Dec-04	Groundwater recirculation initiated		Electron donor addition initiated	
28-Dec-04	Groundwater recirculation ended		Electron donor addition ended	
26-Jan-05				Groundwater monitoring
9-Mar-05				Groundwater monitoring
23-May-05				Groundwater monitoring
18-Oct-05				Groundwater monitoring
21-Oct-05	Groundwater recirculation initiated			
2-Nov-05				Groundwater monitoring
7-Nov-05		Tracer addition initiated	Electron donor addition initiated	
7-Nov-05		Tracer monitoring initiated		
10-Nov-05		Tracer addition ended		
30-Nov-05			Electron donor addition ended	
19-Dec-05		Tracer monitoring ended		Groundwater monitoring
20-Dec-05	Groundwater recirculation ended			
30-Jan-06				Groundwater monitoring
16-Mar-06				Groundwater monitoring
8-May-06				Groundwater monitoring (ORP Only)
20-Jun-06				Groundwater monitoring (ORP Only)

Notes: Date listed for groundwater monitoring is the date the event was started. Monitoring was typically done over 2-3 day

consumed by: 1) demand of non-target compounds including the very high concentrations of sulfate; 2) demand of minerals present in the native geological material; and 3) normal microbiological metabolic processes.

The first and second amendment cycles were conducted March 25, 2004 to April 14, 2004 and December 3 to December 28, 2004. During these periods, groundwater was extracted from 16EW12B and 16EW14B at rates of about 0.9 gpm and 1.7 gpm respectively. A total of 273 gallons of a 60% sodium lactate solution (electron donor) was added in the first and 443 gallons in the second cycle. The electron donor was added to the three injection wells (16EW15, 16EW13 and 16EW11), intermediate injection wells (IW-1 through IW-8), and extraction wells (immediately after the extraction pumps were shut off) to provide complete coverage across the biobarrier in the least amount of time.

The third amendment cycle was conducted between November 7, 2005 and November 30, 2005. During this amendment period, groundwater was extracted from 16EW14B at a rate of 1.7 gpm and injected into 16EW12B. A total of 1,105 gallons of 60% sodium lactate solution was added to the injection and intermediate wells.

During the amendment cycle, electron donor was added in batches, following the schedule presented in Table 5-3. At the conclusion of each electron donor delivery cycle, the recirculation system was shut off and the passive phase of operation was initiated. At the conclusion of each cycle, subsequent monitoring of the system involved the collection of groundwater samples from the performance monitoring wells.

5.6 SAMPLING METHODS

Samples were collected by CES, the local on-site environmental contractor (under subcontract to Geosyntec), following protocols established in Section 3.6.7 and Appendix A of the Demonstration Plan (Geosyntec, 2003). Analyses were conducted by BioInsite, LLC (BioInsite) or by STL located in Houston, Texas. Details of analytical methods, container size and type, preservation method, and sample holding times are presented in the Demonstration Plan (Geosyntec, 2003).

5.7 SAMPLING RESULTS

This section presents the results obtained during the demonstration. Section 5.7.1 presents data collected during baseline monitoring; Section 5.7.2 presents the results of the first tracer test; Section 5.7.3 presents the results of the second tracer testing; Section 5.7.4 presents the results of perchlorate analysis; Section 5.7.5 presents the results of analysis of other groundwater parameters; and Section 5.7.6 presents the results of groundwater level monitoring.

TABLE 5-3: LACTATE INJECTION SCHEDULE
Site 16 Landfill, LHAAP, Karnack, Texas

Date	WilClear Solution[1] Injected Into Well (Gallons)														
	IW-1	IW-2	IW-3	IW-4	IW-5	IW-6	IW-7	IW-8	EW11	EW13	EW15	EW12	EW12B	EW14	EW14B	Total
Injection Round 1																
25-Mar-04	5	5	5	5	5	5	5	5	5	5	5	0	0	0	0	55
27-Mar-04	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	0	0	0	0	27.5
29-Mar-04	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	0	0	0	0	27.5
31-Mar-04	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	0	0	0	0	27.5
2-Apr-04	2	2	2	2	2	2	2	2	2	2	2	0	0	0	0	22
5-Apr-04	2	2	2	2	2	2	2	2	2	2	2	0	0	0	0	22
7-Apr-04	2	2	2	2	2	2	2	2	2	2	2	0	0	0	0	22
9-Apr-04	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	0	0	0	0	16.5
12-Apr-04	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	0	0	0	0	16.5
14-Apr-04	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	0	0	0	0	16.5
15-Apr-04	0	0	0	0	0	0	0	0	0	0	0	5	5	5	5	20
Total Round 1	23	23	23	23	23	23	23	23	23	23	23	5	5	5	5	273
Injection Round 2																
3-Dec-04	5	5	5	5	5	5	5	5	5	5	5	0	0	0	0	55
6-Dec-04	5	5	5	5	5	5	5	5	5	5	5	0	0	0	0	55
8-Dec-04	5	5	5	5	5	5	5	5	5	5	5	0	0	0	0	55
10-Dec-04	5	5	5	5	5	5	5	5	5	5	5	0	0	0	0	55
13-Dec-04	5	5	5	5	5	5	5	5	5	5	5	0	0	0	0	55
14-Dec-04	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	0	0	0	0	27.5
16-Dec-04	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	0	0	0	0	27.5
17-Dec-04	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	0	0	0	0	27.5
20-Dec-04	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	0	0	0	0	27.5
21-Dec-04	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	0	0	0	0	27.5
23-Dec-04	0	0	0	0	0	0	0	0	0	0	0	7.5	7.5	7.5	7.5	30
Total Round 2	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	7.5	7.5	7.5	7.5	443
Injection Round 3																
7-Nov-05	10	10	10	10	10	10	10	10	10	10	10	10	10	0	0	130
9-Nov-05	10	10	10	10	10	10	10	10	10	10	10	10	10	0	0	130
11-Nov-05	10	10	10	10	10	10	10	10	10	10	10	10	10	0	0	130
14-Nov-05	10	10	10	10	10	10	10	10	10	10	10	10	10	0	0	130
15-Nov-05	10	10	10	10	10	10	10	10	10	10	10	10	10	0	0	130
17-Nov-05	10	10	10	10	10	10	10	10	10	10	10	10	10	0	0	130
18-Nov-05	5	5	5	5	5	5	5	5	5	5	5	5	5	0	0	65
21-Nov-05	5	5	5	5	5	5	5	5	5	5	5	5	5	0	0	65
26-Nov-05	5	5	5	5	5	5	5	5	5	5	5	5	5	0	0	65
28-Nov-05	5	5	5	5	5	5	5	5	5	5	5	5	5	0	0	65
30-Nov-05	5	5	5	5	5	5	5	5	5	5	5	5	5	0	0	65
Total Round 3	85	85	85	85	85	85	85	85	85	85	85	85	85	0	0	1105

Notes: [1] - WilClear Solution: 60% Sodium Lactate by mass, 10.9 lbs/gal

5.7.1 Baseline Conditions

This section presents the results of baseline monitoring conducted prior to the injection of electron donor at the Site.

Groundwater Elevation Monitoring

Historic groundwater data obtained from LHAAP was reviewed to evaluate groundwater flow directions over time in the vicinity of the demonstration area. Appendix E contains an assessment of this data and measurements collected during the demonstration.

Evaluation of historic data showed the following:

- Groundwater flow directions in the vicinity of the demonstration area have generally been within 10^{o} to the north and 10^{o} to the south of due east;
- The magnitude of the gradient varies between 0.003 and 0.007 feet per feet (ft/ft); and
- There is some seasonal variability in the magnitude of the gradient with higher gradients observed in the spring and summer but are within the range typically observed at the Site.

Figure 5-11 shows the groundwater elevations during the baseline sampling event in December 2003. The change in groundwater elevation, in the vicinity of the recirculation and monitoring wells are too small to resolve groundwater flow direction and magnitude, but measurements from the recirculation wells and downgradient wells 16WW35 and 16WW36 are consistent with an eastward groundwater flow direction and a gradient with a magnitude in the range of 0.006 and 0.007 ft/ft.

Groundwater Chemistry

Table 5-4 includes baseline chemistry data collected after groundwater recirculation was initiated but before the addition of electron donor. A complete set of baseline groundwater chemistry data is presented in Appendix F along with other chemistry data collected during the demonstration. Figure 5-12a shows perchlorate concentrations in samples collected from wells in March 2004 prior to initiation of electron donor addition. Figure 5-13a shows ORP in samples collected from wells in March 2004 prior to initiation of electron donor addition.

Baseline perchlorate concentrations in groundwater samples collected in March 2004 (Figure 5-12a) ranged from non-detect up to 1,700 µg/L in the upgradient monitoring well 16PM03 The ORP values (Figure 5-13a) were generally high (greater than positive 150 mV).

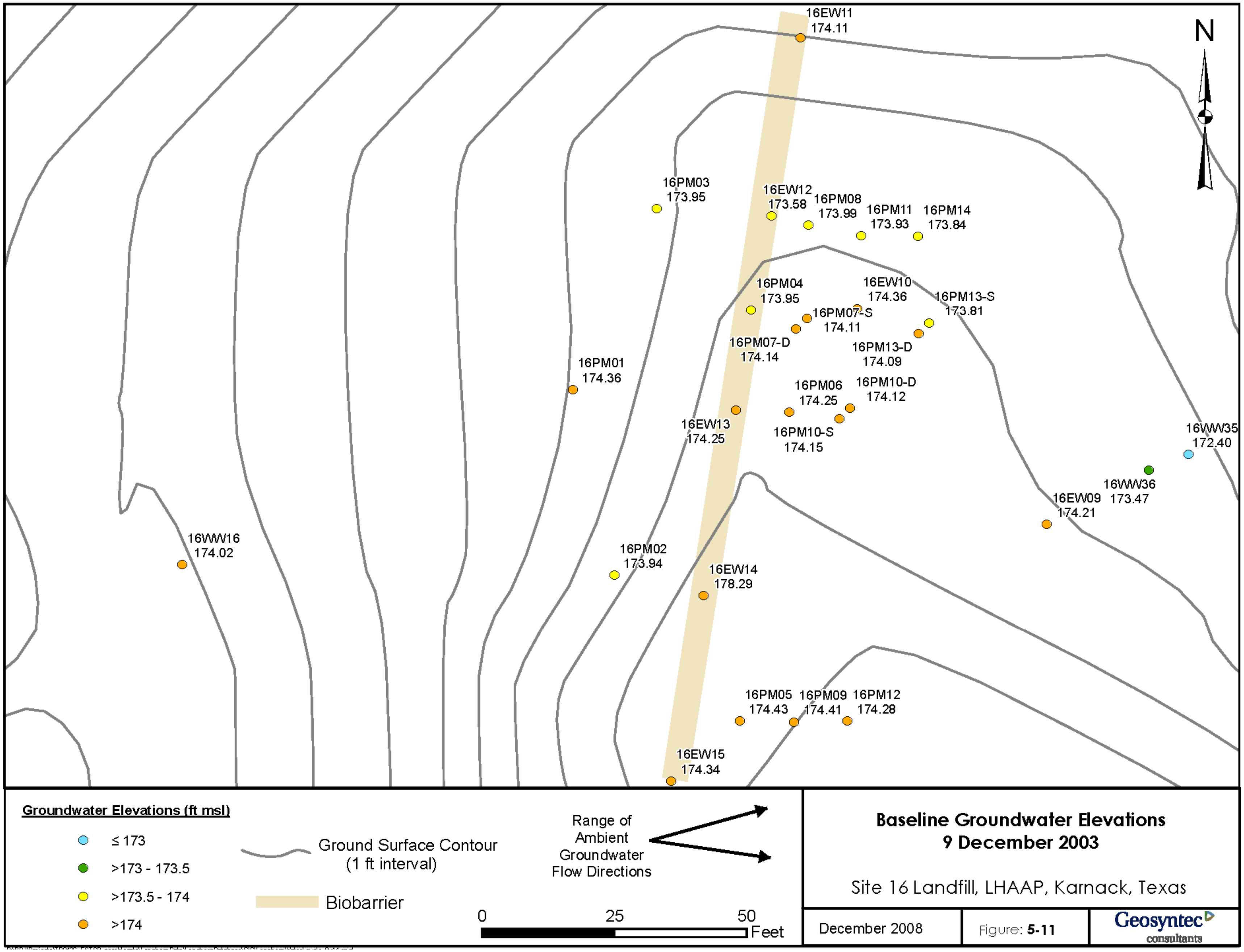

16EW11
174.11
N
16PM03
173.95
16EW12
173.58
16PM08
173.99
16PM11
173.93
16PM14
173.84
16PM04
173.95
16EW10
174.36
16PM13-S
173.81
16PM07-S
174.11
16PM07-D
174.14
16PM13-D
174.09
16PM01
174.36
16PM06
174.25
16PM10-D
174.12
16EW13
174.25
16PM10-S
174.15
16WW35
172.40
16WW36
173.47
16EW09
174.21
16WW16
174.02
16PM02
173.94
16EW14
178.29
16PM05
174.43
16PM09
174.41
16PM12
174.28
16EW15
174.34
Groundwater Elevations (ft msl)
≤ 173
>173 - 173.5
>173.5 - 174
>174
Ground Surface Contour
(1 ft interval)
Biobarrier
Range of
Ambient
Groundwater
Flow Directions
0
25
50
Feet
Baseline Groundwater Elevations
9 December 2003
Site 16 Landfill, LHAAP, Karnack, Texas
December 2008
Figure: 5-11
Geosyntec
consultants

TABLE 5-4: SUMMARY OF GROUNDWATER MONITORING RESULTS
Site 16 Landfill, LHAAP, Karnack, Texas

Well ID	Date	Dissolved Oxygen (mg/L)	Oxidation-Reduction Potential (mV)	pH (std. units)	Perchlorate (µg/L)	Sulfate (mg/L)	Acetate (µmol/L)	Iron (mg/L)	Manganese (mg/L)	Arsenic (mg/L)
16EW09	24-Mar-04	1.43	108	5.9	749	4,790	13	23	9.4	--
16EW09	20-May-04	0.63	68	5.9	373	3,320	22	5	6.8	--
16EW09	02-Dec-04	0.82	137	6.0	66	--	--	--	--	0.0100 U
16EW09	09-Mar-05	--	104	6.2	128	--	--	--	--	--
16EW09	14-Mar-06	--	--	--	4.00U	--	--	--	--	
16EW10	23-Mar-04	1.42	--	6.1	111	2,190	111	18	3.1	--
16EW10	20-May-04	0.56	44	6.1	187	1,700	75	5.9	2.1	--
16EW10	02-Dec-04	0.44	62	6.1	31	--	--	--	--	0.0100 U
16EW10	09-Mar-05	--	61	7.1	55	--	--	--	--	--
16EW10	14-Mar-06	--	--	--	4.00 U	--	--	--	--	--
16EW12B	24-Mar-04	1.68	223	6.4	1,040	2,730	12.5 U	0.400 U	1.3	--
16EW12B	20-May-04	0.15	-32	6.2	63	1,360	1,890	6.0	0.98	--
16EW12B	02-Dec-04	0.98	12	6.5	18	--	--	--	--	0.0100 U
16EW12B	09-Mar-05	--	-199	6.9	22	--	--	--	--	--
16EW12B	14-Mar-06	--	--	--	4.00 U	--	--	--	--	--
16EW14B	24-Mar-04	1.8	206	6.2	1,000	3,800	12.5 U	0.73	6.1	--
16EW14B	20-May-04	<0.0	-99	6.2	142	1,680	12,100	62	5.4	--
16EW14B	02-Dec-04	1.88	35	6.1	38	--	--	--	--	0.0100 U
16EW14B	09-Mar-05	--	-178	7.0	4.00 U	--	--	--	--	--
16PM01	23-Mar-04	0.62	8	6.1	4.00 U	206	12.5 U	16	1.4	--
16PM01	18-May-04	1.32	21	6.3	5	190	12.5 U	10	1.4	--
16PM01	01-Dec-04	3.28	59	6.2	4.00 U	--	--	--	--	0.0100 U
16PM01	10-Mar-05	--	11	6.2	4.00 U	--	--	--	--	--
16PM01	14-Mar-06	--	--	--	4.00 U	--	--	--	--	--
16PM02	23-Mar-04	2.78	84	5.6	4.00 U	316	12.5 U	4.5	1.6	--
16PM02	18-May-04	0.67	147	5.6	9	260	12.5 U	8.4	1.8	--
16PM02	01-Dec-04	3.06	170	5.5	11	--	--	--	--	0.0100 U
16PM02	10-Mar-05	--	121	5.6	153	--	--	--	--	--
16PM02	14-Mar-06	--	--	--	19.0	--	--	--	--	--
16PM03	23-Mar-04	1.86	643	6.3	1,690	470	12.5 U	4.7	0.27	--
16PM03	18-May-04	0.63	127	6.3	1,600	414	12.5 U	0.89	0.19	--
16PM03	01-Dec-04	2.91	117	6.3	1,620	--	--	--	--	0.0100 U
16PM03	10-Mar-05	--	66	6.4	1,180	--	--	--	--	--
16PM03	14-Mar-06	--	--	--	4,551	--	--	--	--	--
16PM04	23-Mar-04	1.54	417	6.1	286	1,430	13.1	1.1	1.4	--
16PM04	18-May-04	0.28	73	6.2	190	975	76	4.2	1.1	--
16PM04	01-Dec-04	3.15	70	6.2	29.9	--	--	--	--	0.0100 U
16PM04	10-Mar-05	--	31	6.2	14	--	--	--	--	--
16PM04	14-Mar-06	--	--	--	4.00 U	--	--	--	--	--

TABLE 5-4: SUMMARY OF GROUNDWATER MONITORING RESULTS
Site 16 Landfill, LHAAP, Karnack, Texas

Well ID	Date	Dissolved Oxygen (mg/L)	Oxidation-Reduction Potential (mV)	pH (std. units)	Perchlorate (µg/L)	Sulfate (mg/L)	Acetate (µmol/L)	Iron (mg/L)	Manganese (mg/L)	Arsenic (mg/L)
16PM05	24-Mar-04	2.56	216	6.0	883	3,540	12.5 U	5.3	2.2	--
16PM05	18-May-04	1.04	33	5.9	134	3,010	36	19	5.4	--
16PM05	01-Dec-04	3.55	122	5.9	12	--	--	--	--	0.0100 U
16PM05	09-Mar-05	--	-22	6.9	14	--	--	--	--	--
16PM05	14-Mar-06	--	--	--	4.00 U	--	--	--	--	--
16PM06	23-Mar-04	2.15	--	6.2	968	3,730	12.5 U	30	8.3	--
16PM06	19-May-04	3.25	-62	6.5	374	3,250	643	126	7.7	--
16PM06	01-Dec-04	5	55	6.1	6.8	--	--	--	--	0.0100 U
16PM06	09-Mar-05	--	-6	6.9	4.00 U	--	--	--	--	--
16PM06	14-Mar-06	--	--	--	7.0	--	--	--	--	--
16PM07-D	23-Mar-04	1.26	--	6.1	4.00 U	837	62.3	1.9	1.3	--
16PM07-D	19-May-04	0.74	70	6.2	63	693	43	3.4	1.1	--
16PM07-D	01-Dec-04	1.86	71	6.0	8.2	--	--	--	--	0.0100 U
16PM07-D	09-Mar-05	--	65	6.9	4.00 U	--	--	--	--	--
16PM07-D	14-Mar-06				26.5					
16PM07-S	23-Mar-04	1.5	--	6.1	39	810	45.9	3.7	0.83	--
16PM07-S	19-May-04	0.96	121	6.1	177	975	40	2.1	0.84	--
16PM07-S	01-Dec-04	3.33	249	6.1	5.5	--	--	--	--	0.0100 U
16PM07-S	09-Mar-05	--	96	6.8	4.00 U	--	--	--	--	--
16PM07-S	14-Mar-06	--	--	--	10.0	--	--	--	--	--
16PM08	23-Mar-04	1.25	132	6.3	129	1,040	13.1	0.44	0.98	--
16PM08	19-May-04	1.08	181	6.3	126	975	33	0.48	0.85	--
16PM08	01-Dec-04	3.06	96	6.3	30	--	--	--	--	0.0100 U
16PM08	10-Mar-05	--	136	6.3	34	--	--	--	--	--
16PM08	14-Mar-06	--	--	--	4.00 U	--	--	--	--	--
16PM09	24-Mar-04	1.16	206	5.8	918	2,070	144	1.2	4.4	--
16PM09	18-May-04	1.14	63	6.1	146	1,590	12.5 U	3.3	11	--
16PM09	01-Dec-04	2.52	137	5.9	22	--	--	--	--	0.0100 U
16PM09	09-Mar-05	--	20	6.8	6	--	--	--	--	--
16PM09	14-Mar-06	--	--	--	4.00 U	--	--	--	--	--
16PM10-D	24-Mar-04	0.71	212	5.0	69	965	45.9	7.4	3.7	--
16PM10-D	19-May-04	1.15	164	5.2	156	885	25	6.8	3.8	--
16PM10-D	01-Dec-04	2.17	108	5.4	37	--	--	--	--	0.0100 U
16PM10-D	09-Mar-05	--	113	6.9	4.00 U	--	--	--	--	--
16PM10-D	14-Mar-06	--	--	--	4.00 U	--	--	--	--	--
16PM10-S	24-Mar-04	1.02	227	5.8	669	3,410	12.5 U	4.0	9.0	--
16PM10-S	19-May-04	0.96	-54	6.4	340	2,600	67	59	38	--
16PM10-S	01-Dec-04	2.69	40	6.2	8.7	--	--	--	--	0.036
16PM10-S	09-Mar-05	--	-55	6.9	4.00 U	--	--	--	--	--
16PM10-S	14-Mar-06	--	--	--	7.5	--	--	--	--	--

TABLE 5-4: SUMMARY OF GROUNDWATER MONITORING RESULTS
Site 16 Landfill, LHAAP, Karnack, Texas

Well ID	Date	Dissolved Oxygen (mg/L)	Oxidation-Reduction Potential (mV)	pH (std. units)	Perchlorate (µg/L)	Sulfate (mg/L)	Acetate (µmol/L)	Iron (mg/L)	Manganese (mg/L)	Arsenic (mg/L)
16PM11	23-Mar-04	1.49	216	6.2	161	1,100	12.5 U	1.1	1.6	--
16PM11	20-May-04	2.19	221	6.3	258	1,460	33	0.57	1.2	--
16PM11	01-Dec-04	3.85	112	6.2	41	--	--	--	--	0.0100 U
16PM11	10-Mar-05	--	62	6.2	22	--	--	--	--	--
16PM11	14-Mar-06	--	--	--	4.00 U	--	--	--	--	--
16PM12	24-Mar-04	1.51	208	5.7	132	4,090	12.5 U	1.5	3.5	--
16PM12	18-May-04	--	--	--	--	--	--	2.5	3.3	--
16PM12	19-May-04	0.78	107	5.8	72	3,200	19	--	--	--
16PM12	01-Dec-04	2.57	141	5.8	96	--	--	--	--	0.0100 U
16PM12	09-Mar-05	--	31	6.8	373	--	--	--	--	--
16PM12	14-Mar-06	--	--	--	7,684	--	--	--	--	--
16PM13-D	23-Mar-04	1.27	--	5.6	220	2,460	95.1	2.5	4.0	--
16PM13-D	19-May-04	0.77	180	5.8	279	1,910	89	1.2	3.5	--
16PM13-D	01-Dec-04	2.2	206	5.7	395	--	--	--	--	0.0100 U
16PM13-D	09-Mar-05	--	167	6.9	71	--	--	--	--	--
16PM13-D	14-Mar-06	--	--	--	4.00 U	--	--	--	--	--
16PM13-S	23-Mar-04	1.19	--	6.1	4.00 U	610	21.3	2.7	0.95	--
16PM13-S	19-May-04	0.99	177	6.0	165	1,200	25	1.3	2.1	--
16PM13-S	01-Dec-04	2.31	239	6.0	18	--	--	--	--	0.0100 U
16PM13-S	09-Mar-05	--	130	6.9	5.6	--	--	--	--	--
16PM13-S	14-Mar-06	--	--	--	4.00 U	--	--	--	--	--
16PM14	23-Mar-04	1.6	250	6.2	428	3,000	21.3	1.3	2.9	--
16PM14	19-May-04	--	--	--	488	2,620	31	--	--	--
16PM14	20-May-04	1.71	176	6.3	--	--	--	2.1	3.2	--
16PM14	01-Dec-04	2.79	149	6.3	389	--	--	--	--	0.0100 U
16PM14	10-Mar-05	--	129	6.3	179	--	--	--	--	
16PM14	14-Mar-06	--	--	--	4.0	--	--	--	--	--

Notes: Data listed for 9-Mar-05 includes samples collected on 9-Mar-05 and 10-Mar-05

mg/L - milligrams per liter

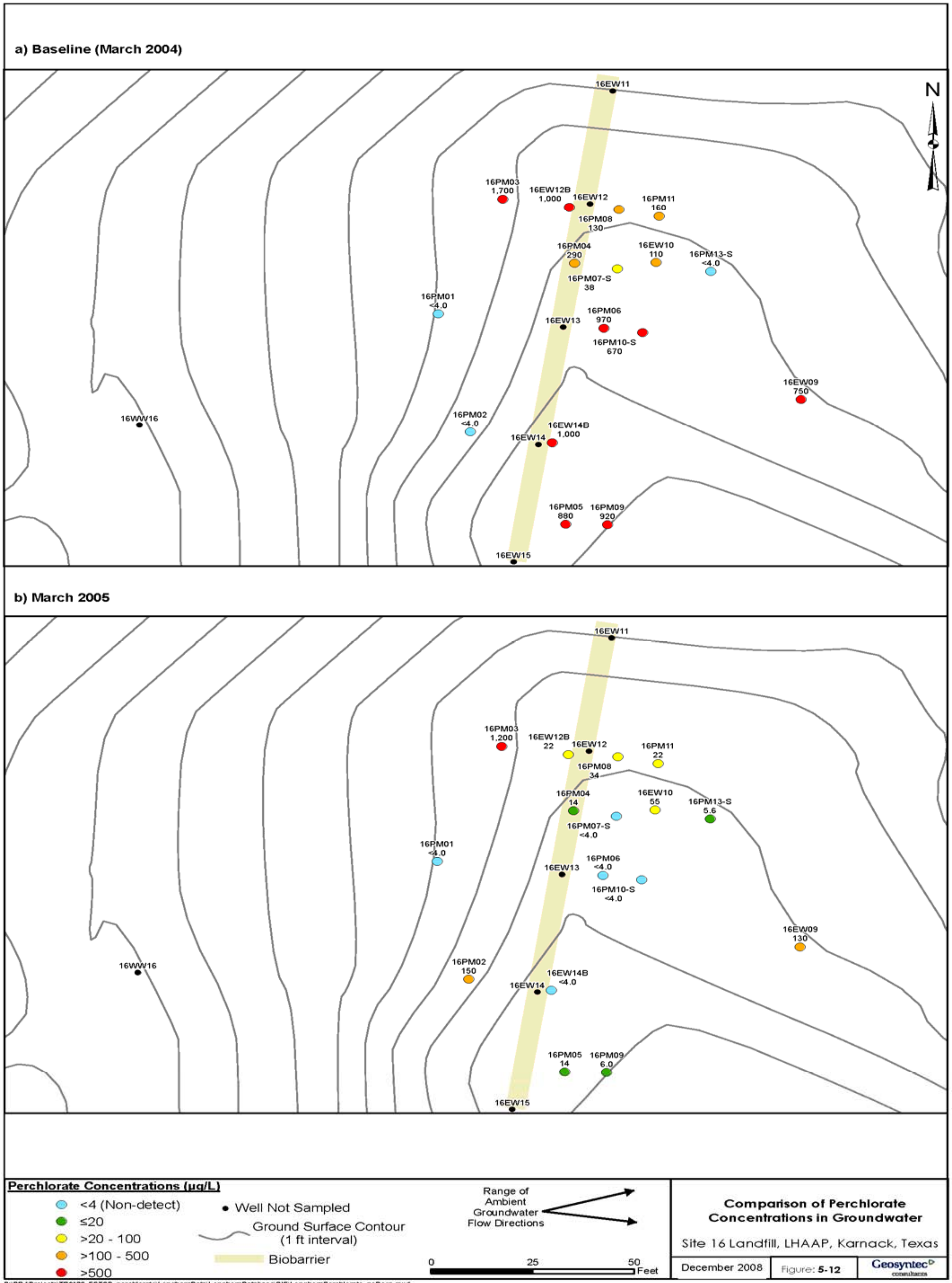
mV - millivolt

µg/L - micrograms per liter

µmol/L - micromoles per liter

(green shading) - baseline sample prior to electron donor addition

-- - not analyzed



a) Baseline (March 2004)
N
16EW11
16PM03
1,700
16EW12B
1,000
16EW12
16PM11
160
16PM08
130
16PM04
290
16EW10
110
16PM13-S
<4.0
16PM07-S
38
16PM01
<4.0
16PM06
970
16EW13
16PM10-S
670
16EW09
750
16WW16
16PM02
<4.0
16EW14B
1,000
16EW14
16PM05
880
16PM09
920
16EW15
b) March 2005
16EW11
16PM03
1,200
16EW12B
22
16EW12
16PM11
22
16PM08
34
16PM04
14
16EW10
55
16PM13-S
5.6
16PM07-S
<4.0
16PM01
<4.0
16PM06
<4.0
16EW13
16PM10-S
<4.0
16EW09
130
16WW16
16PM02
150
16EW14B
<4.0
16EW14
16PM05
14
16PM09
6.0
16EW15
Perchlorate Concentrations (µg/L)
<4 (Non-detect)
≤20
>20 - 100
>100 - 500
>500
Well Not Sampled
Ground Surface Contour
(1 ft interval)
Biobarrier
Range of
Ambient
Groundwater
Flow Directions
0
25
50
Feet
Comparison of Perchlorate
Concentrations in Groundwater
Site 16 Landfill, LHAAP, Karnack, Texas
December 2008
Figure: 5-12
Geosyntec
consultants
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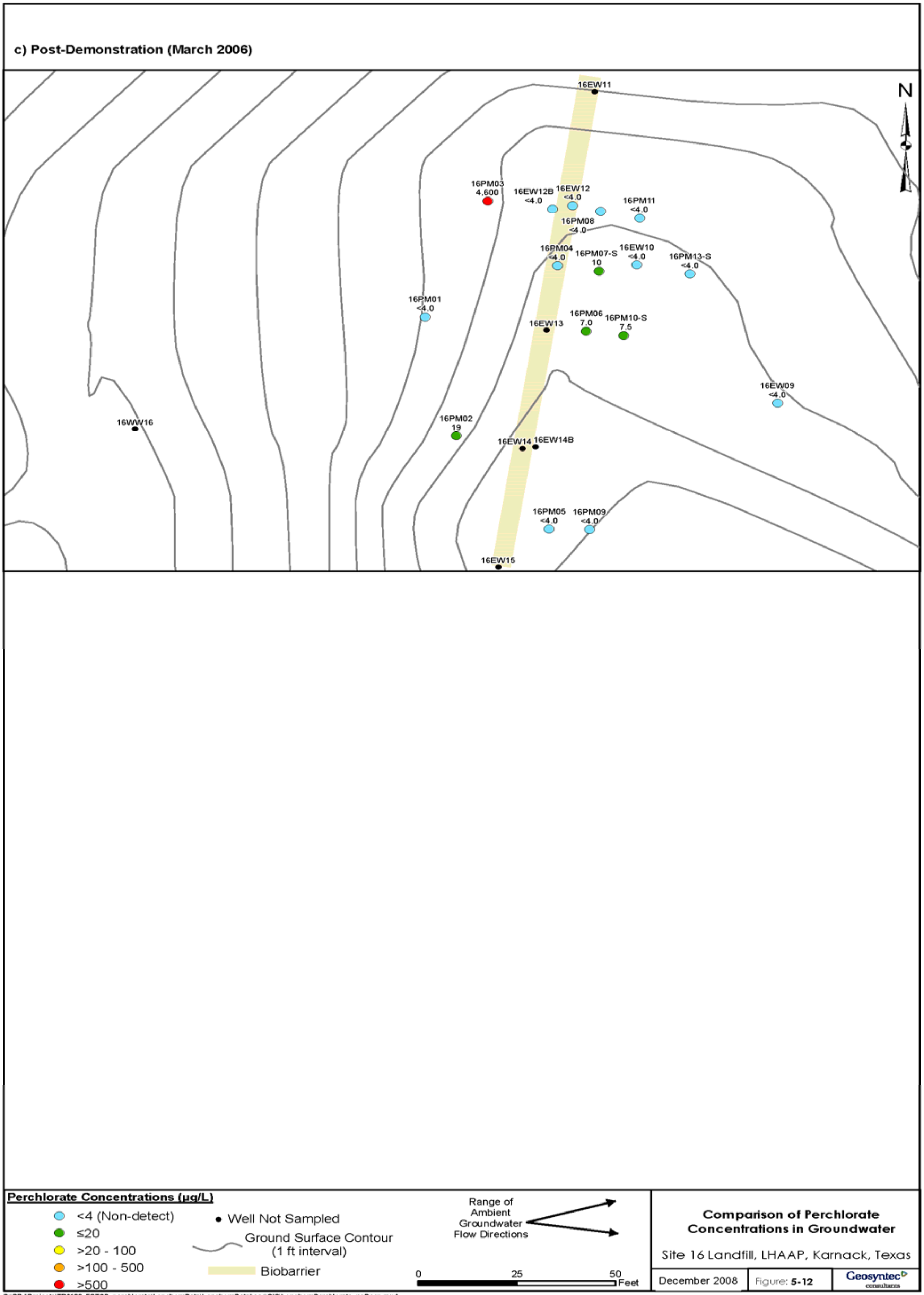
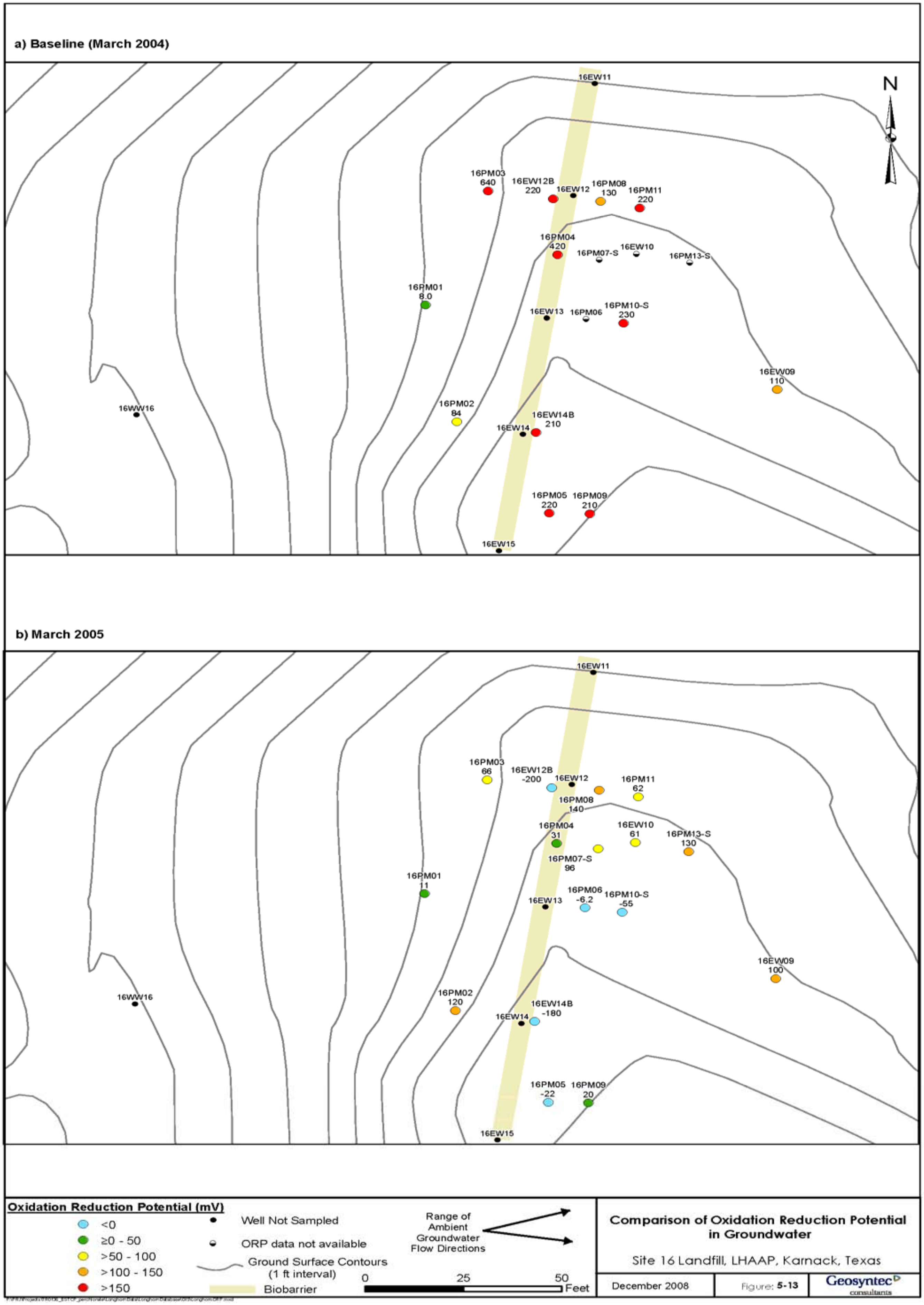
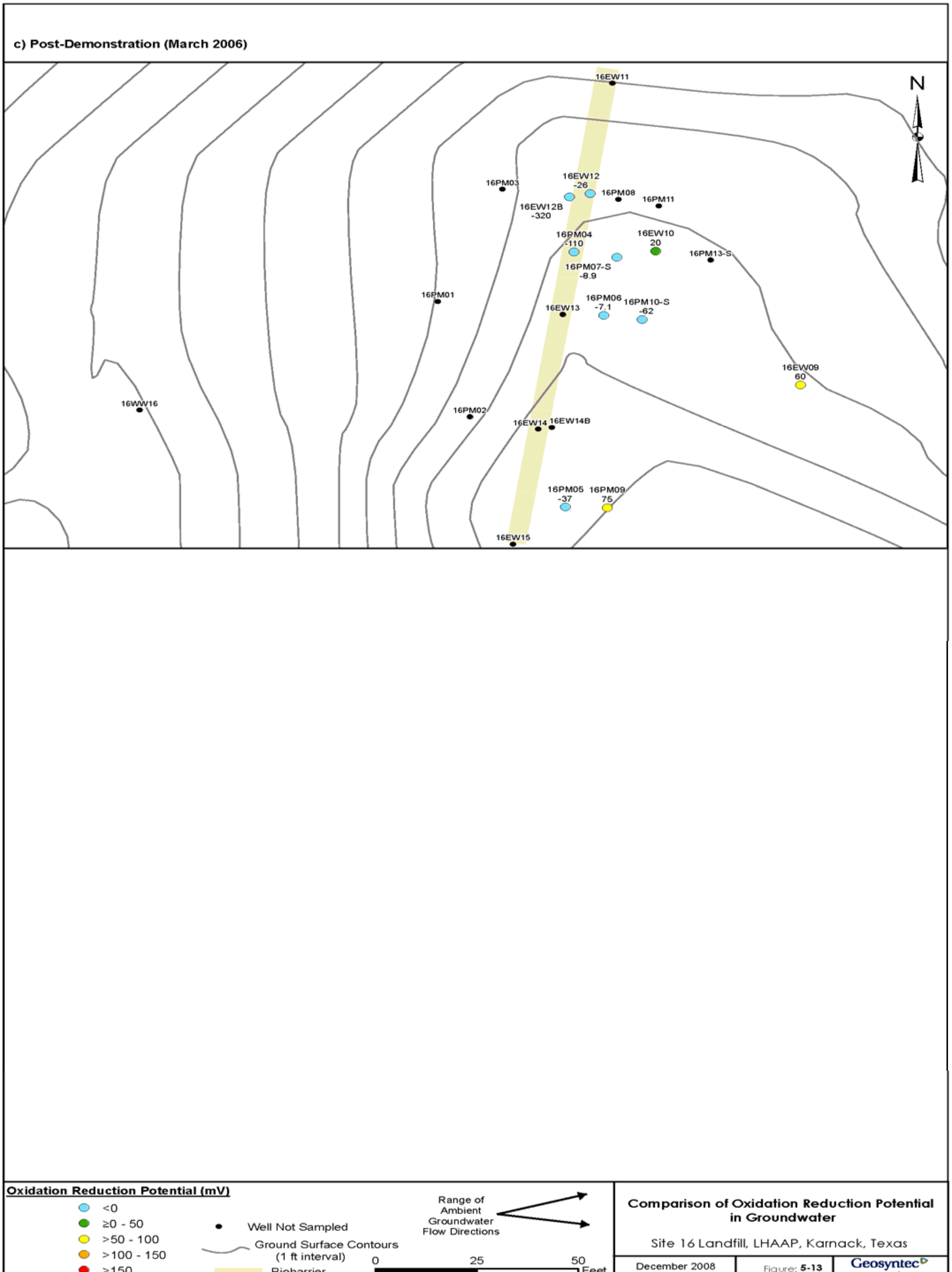

c) Post-Demonstration (March 2006)
N
16EW11
16PM03
4,600
16EW12B
<4.0
16EW12
<4.0
16PM11
<4.0
16PM08
<4.0
16PM04
<4.0
16PM07-S
10
16EW10
<4.0
16PM13-S
<4.0
16PM01
<4.0
16EW13
16PM06
7.0
16PM10-S
7.5
16EW09
<4.0
16WW16
16PM02
19
16EW14
16EW14B
16PM05
<4.0
16PM09
<4.0
16EW15
Perchlorate Concentrations (µg/L)
<4 (Non-detect)
≤20
>20 - 100
>100 - 500
>500
Well Not Sampled
Ground Surface Contour
(1 ft interval)
Biobarrier
Range of
Ambient
Groundwater
Flow Directions
0
25
50
Feet
Comparison of Perchlorate
Concentrations in Groundwater
Site 16 Landfill, LHAAP, Karnack, Texas
December 2008
Figure: 5-12
Geosyntec
consultants
P:\PRJ\Projects\TR0136_ESTCP_perchlorate\LonghornData\LonghornDatabase\GIS\LonghornPerchlorate_noDeep.mxd


a) Baseline (March 2004)
16EW11
N
16PM03
640
16EW12B
220
16EW12
16PM08
130
16PM11
220
16PM04
420
16PM07-S
16EW10
16PM13-S
16PM01
8.0
16EW13
16PM06
16PM10-S
230
16EW09
110
16WW16
16PM02
84
16EW14B
210
16EW14
16PM05
220
16PM09
210
16EW15
b) March 2005
16EW11
16PM03
66
16EW12B
-200
16EW12
16PM11
62
16PM08
140
16PM04
31
16EW10
61
16PM13-S
130
16PM07-S
96
16PM01
11
16PM06
-6.2
16PM10-S
-55
16EW13
16EW09
100
16WW16
16PM02
120
16EW14B
-180
16EW14
16PM05
-22
16PM09
20
16EW15
Oxidation Reduction Potential (mV)
<0
≥0 - 50
>50 - 100
>100 - 150
>150
Well Not Sampled
ORP data not available
Ground Surface Contours
(1 ft interval)
Biobarrier
Range of
Ambient
Groundwater
Flow Directions
0
25
50
Feet
Comparison of Oxidation Reduction Potential
in Groundwater
Site 16 Landfill, LHAAP, Karnack, Texas
December 2008
Figure: 5-13
Geosyntec
consultants


c) Post-Demonstration (March 2006)
N
16EW11
16PM03
16EW12
-26
16PM08
16PM11
16EW12B
-320
16PM04
-110
16EW10
20
16PM13-S
16PM07-S
-8.9
16PM01
16PM06
-7.1
16PM10-S
-62
16EW13
16EW09
60
16WW16
16PM02
16EW14
16EW14B
16PM05
-37
16PM09
75
16EW15
Oxidation Reduction Potential (mV)
<0
≥0 - 50
>50 - 100
>100 - 150
>150
Well Not Sampled
Ground Surface Contours
(1 ft interval)
Biobarrier
Range of
Ambient
Groundwater
Flow Directions
0
25
50
Feet
Comparison of Oxidation Reduction Potential
in Groundwater
Site 16 Landfill, LHAAP, Karnack, Texas
December 2008
Figure: 5-13
Geosyntec
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Microbial Characterization

Table 5-5 presents a summary of the baseline enumeration and molecular analysis for perchlorate-reducers conducted by BioInsite on samples collected in 2003. The complete report is presented in **Appendix G**. The results suggest that the natural population of known perchlorate reducing microorganisms was initially very low.

5.7.2 Results of Tracer Testing

Tracer testing was conducted February to April 2004 and again in November and December 2005. The results of the initial tracer test are discussed below in Section 5.7.2.1 and the results of the second tracer test are discussed in Section 5.7.2.2.

5.7.2.1 Results of First Tracer Testing

A summary of the results of the first tracer test are shown in Figures 5-14, 5-15, 5-16 and 5-17. The figures show the tracer concentrations (either bromide or iodide) in wells along the four recirculation segments. Table 5-6 includes a summary of the tracer recoveries, travel times and results of the mass balance for each segment. Appendix H includes the bromide and iodide monitoring results.

Mass balance calculations were performed to evaluate the transport of tracer between the recirculation wells for each of the four segments in the biobarrier. The mass balances were calculated by taking the area below the concentration versus time curve and multiplying by the extraction flow rate. It was not possible to calculate a mass balance for the intermediate injection wells in the same way because no specific flow data was available for these monitoring locations. The mass balances for the intermediate monitoring points were estimated by taking the area below the concentration versus time curve for the monitoring point and multiplying by the recirculation flow rate. This approach may tend to overestimate the mass recovery, but the relative recoveries within and between segments provide insight into the operation of the recirculation system.

The tracer concentrations and mass balance for intermediate wells in Segments 1, 2 and 4 show consistent movement of the tracer within each segment. The travel time between the injection wells and first intermediate injection well (located 15 feet from the injection well) was typically one to two weeks. The mass balance estimates between the injection wells and the first intermediate wells in Segments 1, 2, and 4 ranged between 57% and 100%. The tracer concentrations and mass balance in intermediate wells in Segment 3 indicate significantly slower movement of the tracer. The slower movement of tracer is consistent with the groundwater flow model that showed some of the water injected into EW-13 being pulled back towards the south into the higher pumping 16EW14B because 16EW12B could not sustain as high a yield.

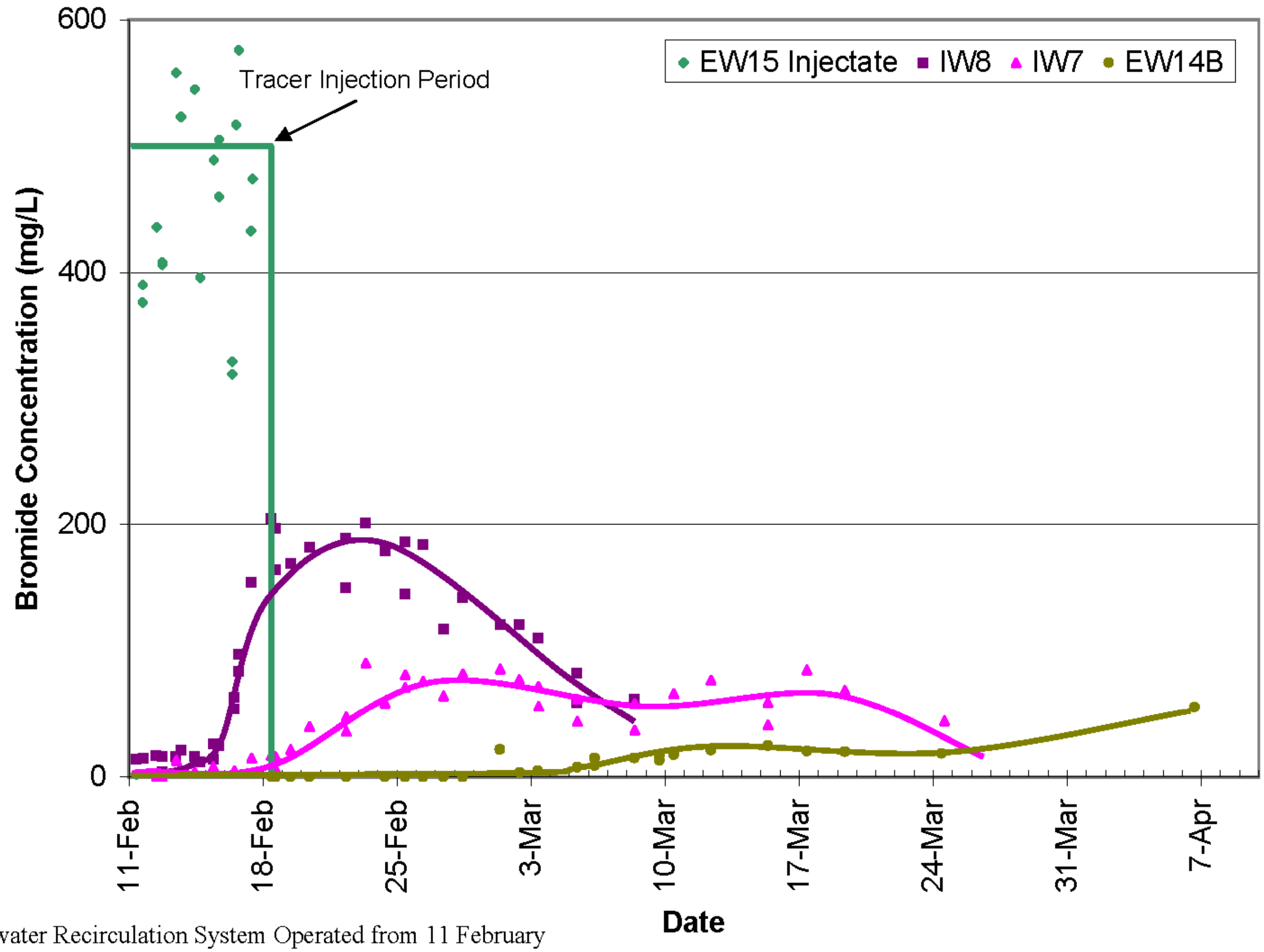
Figures 5-18, 5-19 and 5-20 show the tracer concentrations in the monitoring wells downgradient of the line of recirculation wells. The figures show the concentrations of tracer in

TABLE 5-5: SUMMARY OF BASELINE MICROBIAL ANALYSIS
Site 16 Landfill, LHAAP, Karnack, Texas

	Enumeration Study Results	Molecular Analysis Results			
			Dechloromonas		*Dechlorosoma*
Sample Location and Depth	**Most Probable Number for Perchlorate-Reducing Population (Cells/mL)**	**Universal Primers (control)**	**CKB Primers**	**RCB Primers**	**PS Primers**
BH-4 (28 foot)	ND	(+)	(-)	(+)	(-)
BH-4 (23 foot)	ND	(+)	(+)	(+)	(-)
BH-4 (18 foot)	ND	(+)	(-)	(-)	(-)
BH-2 (27 foot)	ND	(+)	(-)	(-)	(-)
BH-2 (18 foot)	ND	(+)	(-)	(-)	(-)
BH-2 (13 foot)	ND	(+)	(-)	(-)	(-)
BH-2 (8 foot)	ND	(+)	(-)	(-)	(-)
Well Water (BH-2)	ND	(+)	(-)	(-)	(-)

Notes: ND - not detected (less than 10 cells per gram of sample)
CKD - specific strain of *Dechloromonas agitata*
RCB - specific strain of *Dechloromonas aromatica*
PS - specific strain of *Dechlorosoma suillum*

(+) means 16S rDNA was successfully amplified.
(-) means no 16S rDNA was amplified.
BH - Borehole



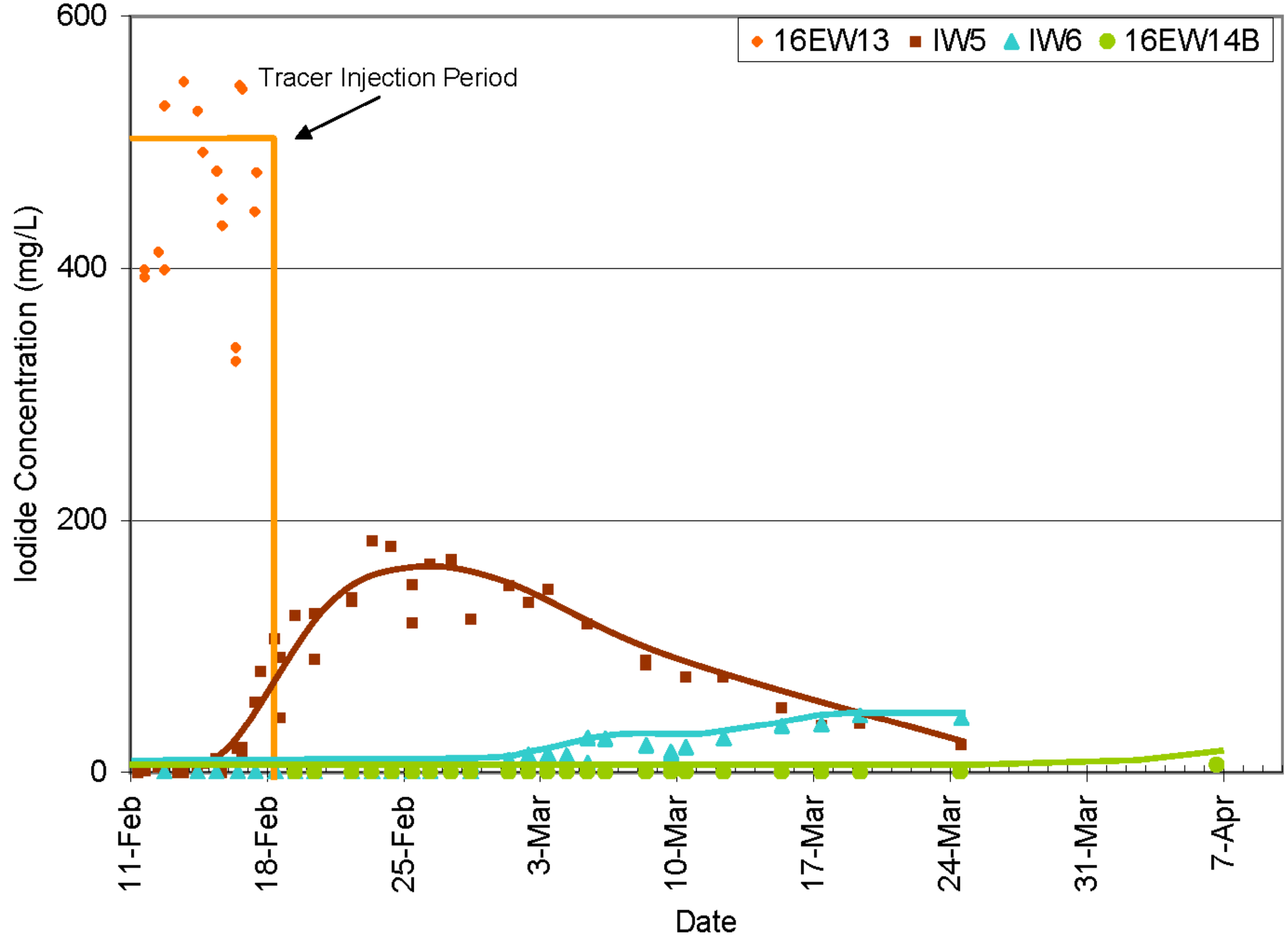
Note: Groundwater Recirculation System Operated from 11 February 2004 to 14 April 2004

Well	IW8	IW7	16EW14B
Distance From 16EW15 (ft)	14	21	35

Tracer Concentrations with Time in Segment 1

Site 16 Landfill, LHAAP, Karnack, Texas

Dec. 2008 | Figure: **5-14** | Geosyntec consultants



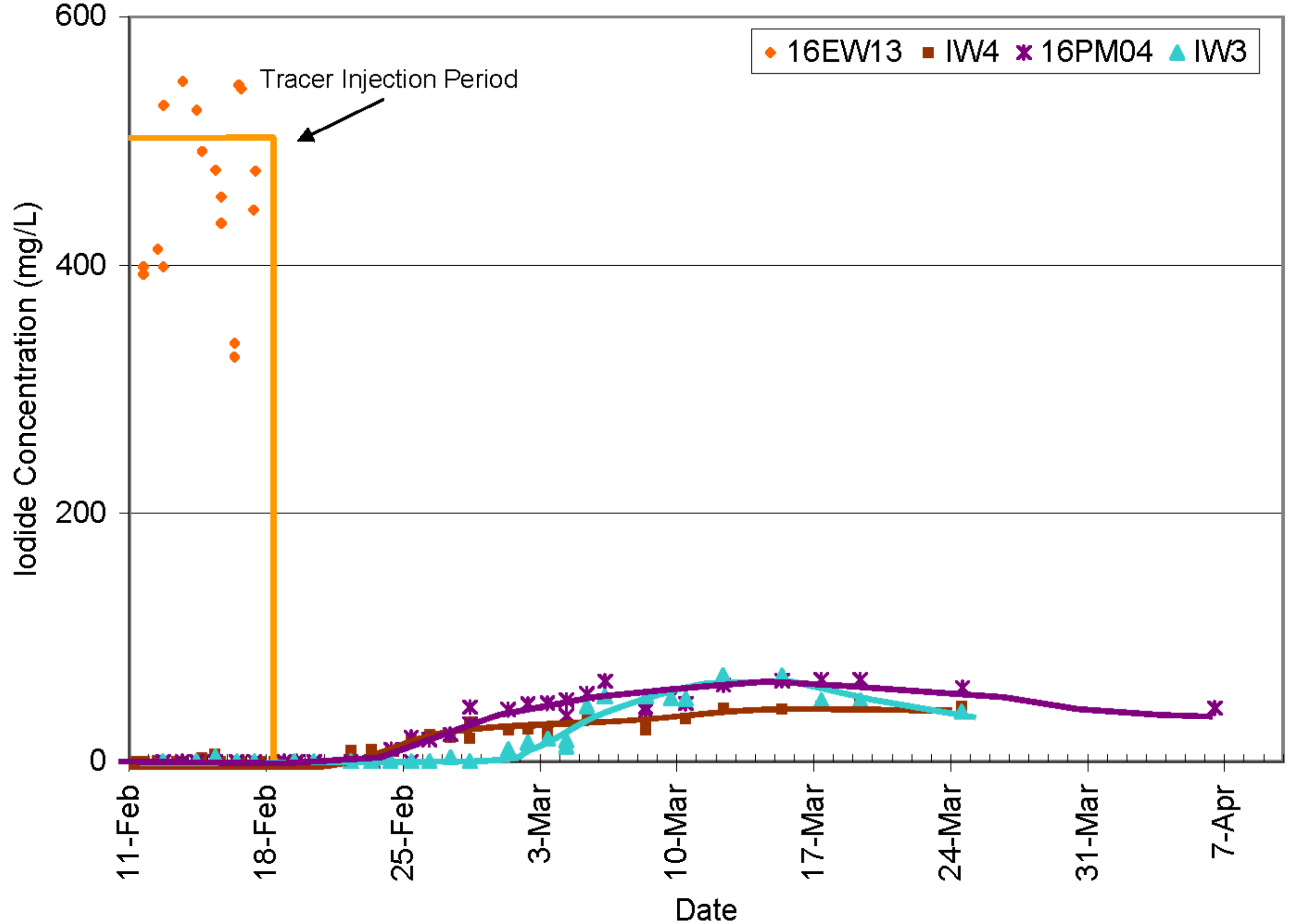
Note: Groundwater Recirculation System Operated from 11 February 2004 to 14 April 2004

Well	IW5	IW6	16EW14B
Distance From 16EW13 (ft)	14	21	35

Tracer Concentrations with Time in Segment 2

Site 16 Landfill, LHAAP, Karnack, Texas

Dec. 2008	Figure: **5-15**	Geosyntec consultants

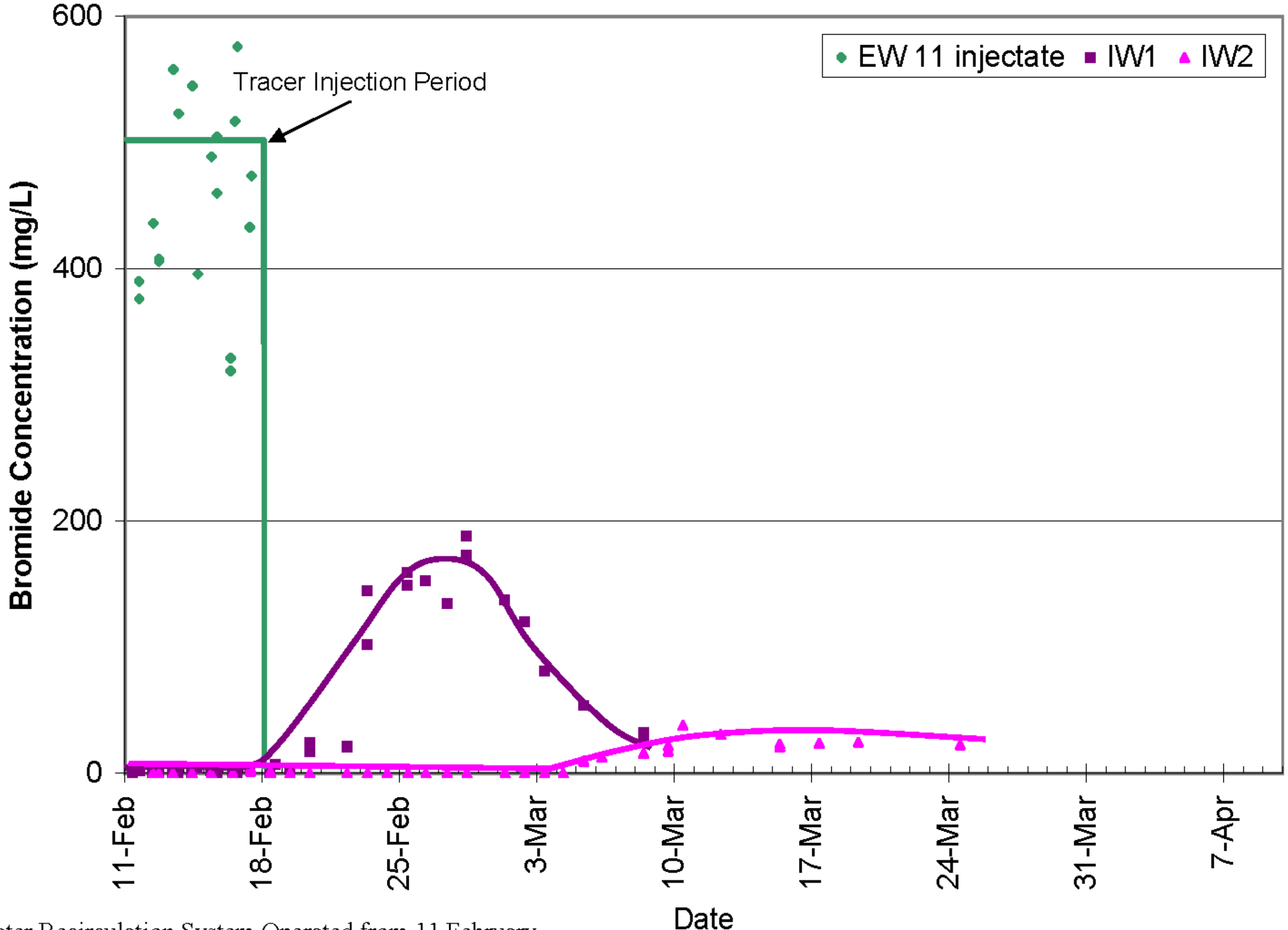


Note: Groundwater Recirculation System Operated from 11 February 2004 to 14 April 2004

Well	IW4	16PM04	IW3	16EW12B*
Distance From 16EW13 (ft)	14	17	21	35

*Tracer Not Detected in EW13B

Tracer Concentrations with Time in Segment 3 Site 16 Landfill, LHAAP, Karnack, Texas		
Dec. 2008	Figure: **5-16**	Geosyntec consultants



Note: Groundwater Recirculation System Operated from 11 February 2004 to 14 April 2004

Well	IW1	IW2	16EW12B*
Distance From 16EW11 (ft)	14	21	35

*Tracer Not Detected in EW13B

Tracer Concentrations with Time in Segment 4

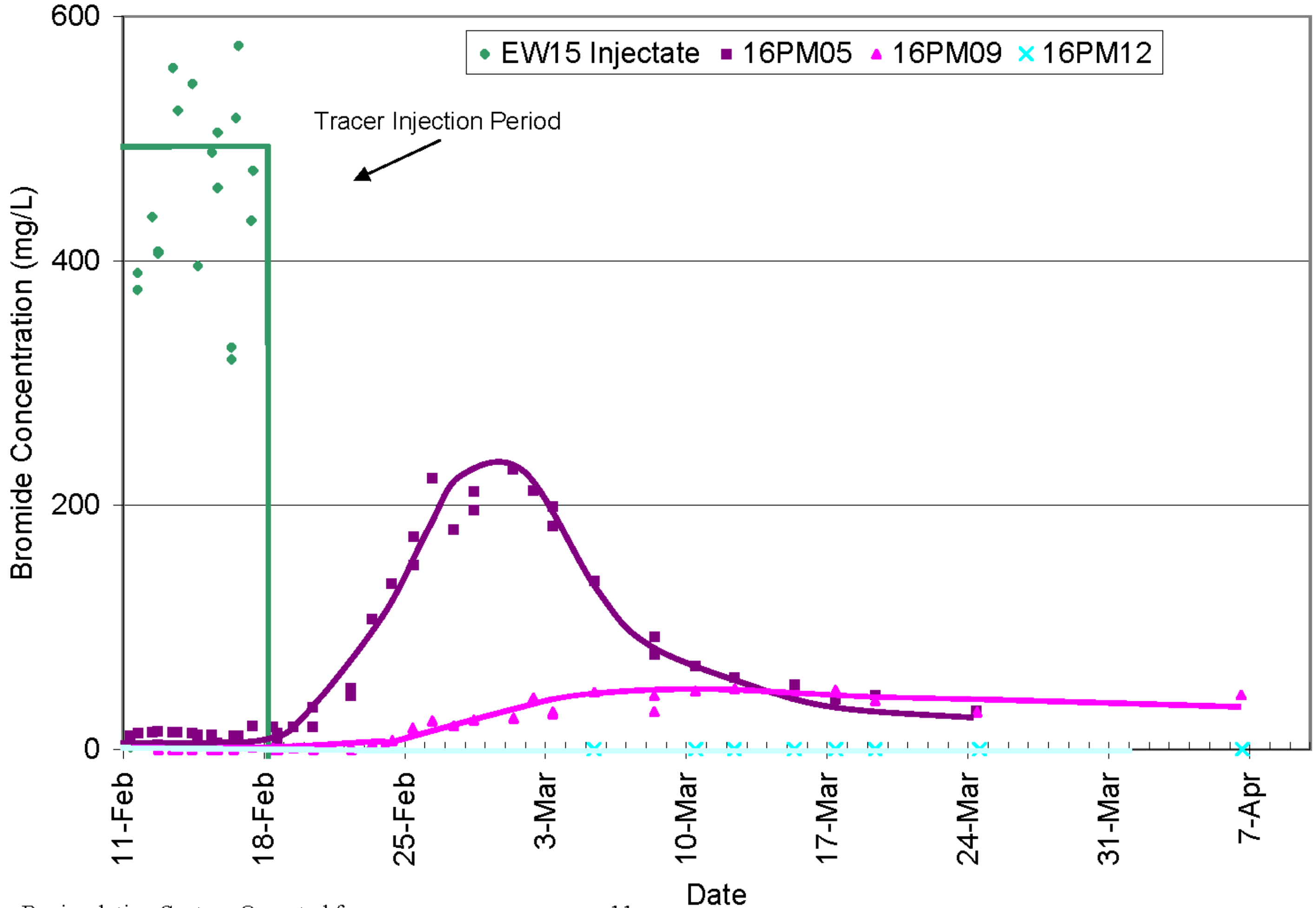
Site 16 Landfill, LHAAP, Karnack, Texas

Dec. 2008 | Figure: **5-17** | Geosyntec consultants

Table 5-6: SUMMARY OF TRACER TEST RESULTS
Site 16 Landfill, LHAAP, Karnack, Texas

	Mass Balance Data				Peak Concentrations	
Well ID	**Mass Injected (kg)**	**Mass Observed (kg)**	**Percent Observed / Recovered**	**Observation Period (days)**	**C/C_o**	**Time (days)**
Segment 1: EW15 to EW14B - Bromide						
EW15	15.4					
IW8		14.7	95.5	26	0.40	8
IW7		10.5	68.3	42	0.14	22
EW14B		1.7	11.1	39	0.11	50
Segment 2: EW13 to EW14B - Iodide						
EW13	15.9					
IW5		16.2	101.4	42	0.32	12
IW6		3.3	20.9	42	0.09	37
EW14B		0.3	2.2	55	-	-
Segment 3: EW13 to EW12B - Iodide						
EW13	15.9					
IW4		6.0	37.4	42	0.09	-
PM4		9.3	58.3	55	-	-
IW3		5.1	32.3	36	0.14	-
EW12B		0	0	42	-	-
Segment 4: EW11 to EW12B - Bromide						
EW11	16.2					
IW1		9.2	56.7	26	0.34	12
IW2		2.5	15.2	42	0.08	25
EW12B		0.4	2.5	42	-	-
Transect 1: 16PM05 - 16PM09 - Bromide						
PM05					0.47	15
PM09					0.10	29
Transect 2: 16PM06 - 16PM10-S - 16PM10-D - Iodide						
PM06					0.51	3.5
PM10-S					0.21	10

Notes: "-" - data insufficient to estimate values



Note: Groundwater Recirculation System Operated from 11 February 2004 to 14 April 2004

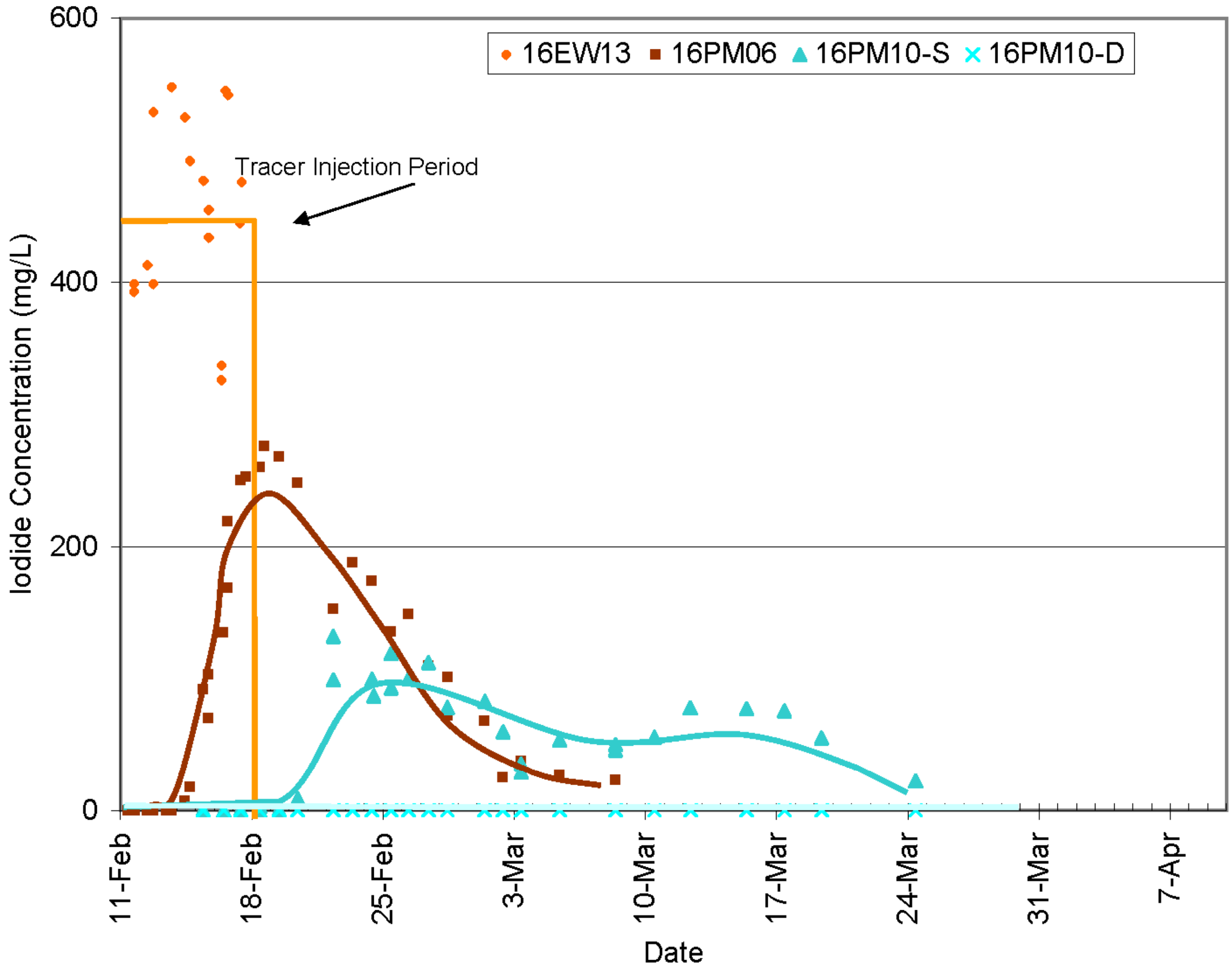
Well	16PM05	16PM09	16PM12
Distance Downgradient From Biobarrier* (ft)	10	21	32

*Line of transect is 10 ft from injection well (16EW15)

Tracer Concentrations with Time in Transect 1

Site 16 Landfill, LHAAP, Karnack, Texas

Dec. 2008 | Figure: **5-18** | Geosyntec consultants



Note: Groundwater Recirculation System Operated from 11 February 2004 to 14 April 2004

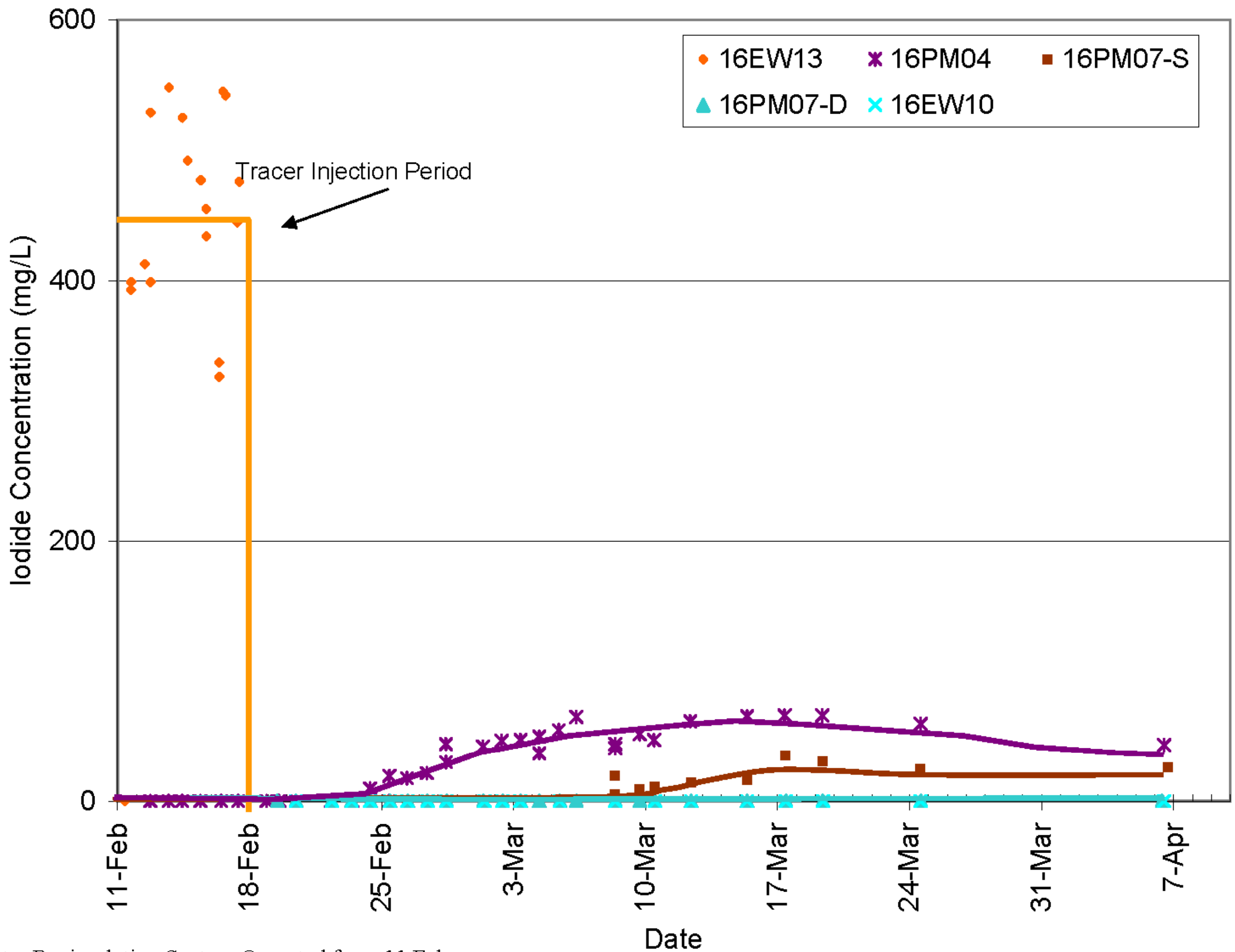
Well	16PM06	16PM10-S	16-PM10-D
Distance Downgradient From Biobarrier* (ft)	14	20	20

*Line of transect is <1ft from injection well (16EW13X)

Tracer Concentrations with Time in Transect 2

Site 16 Landfill, LHAAP, Karnack, Texas

Dec. 2008	Figure: **5-19**	Geosyntec consultants



Note: Groundwater Recirculation System Operated from 11 February 2004 to 14 April 2004

Well	16PM04	16PM07-S	16-PM07-D	16EW10
Distance Downgradient From Biobarrier* (ft)	<1	12	12	22

*Line of transect is 18 ft from injection well (16EW13)

Tracer Concentrations with Time in Transect 3

Site 16 Landfill, LHAAP, Karnack, Texas

Dec. 2008	Figure: **5-20**	Geosyntec consultants

wells along three separate transects which are numbered from the south to the north as follows: Transect 1 includes 16PM05, 16PM09 and 16PM12; Transect 2 includes 16PM06, 16PM10-S, and 16PM10D; and Transect 3 includes 16PM04, 16PM07-S, 6PM07-D and 16EW10.

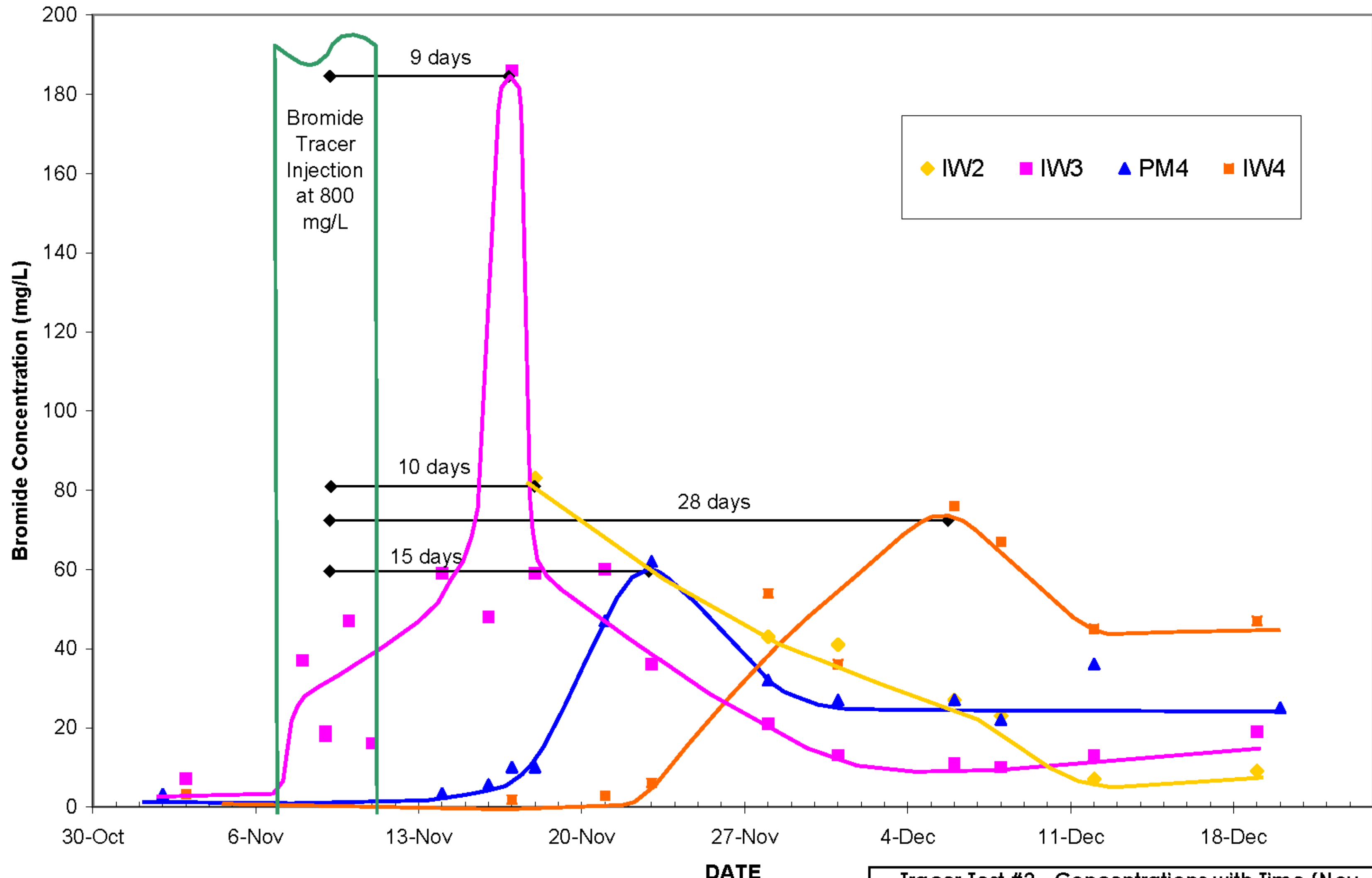
The travel times and percentage of tracer recovered in the transect wells is impacted significantly by the lateral distance between the primary points of injection (16EW11, 16EW13 and 16EW15) and the location of the transect. Transect 1 is approximately 13 feet north of injection well 16EW15; Transect 2 is in a line located immediately downgradient of injection well 16EW13; Transect 3 is in a line located approximately 17 feet north of injection well 16EW13; and Transect 4 is located 35 feet north of injection well 16EW13 and 35 feet to the south of injection well 16EW11. As expected, the shortest travel time and highest tracer concentration were observed in Transect 2, immediately downgradient of well 16EW13. A slightly longer travel time and lower tracer concentrations were observed in Transect 1, located 13 feet transgradient of well 16EW15. Significantly longer travel times and lower tracer concentrations were observed in Transect 3 where the distribution of tracer across the segment was much slower and is located further from the injection well than Transect 1 and 2. No significant concentrations of tracer were observed in Transect 4 located 35 feet from either of the injection wells (16EW11 and 16EW13).

The tracer data also provide information on the connectivity between the injection wells and downgradient monitoring wells. Data from wells 16PM05 and 16PM09 in Transect 1 (Figure 5-18) show that tracer reached both these monitoring wells but, no significant concentrations of tracer were observed in 16PM12, the furthest downgradient monitoring well in this transect. Given the high degree of interbedding of the sand, slit and clay units, it is likely that the more permeable geological units in the vicinity of injection well 16EW15 are not connected with monitoring well 16PM12. Similarly, data from wells 16PM06 and 16PM10-S in Transect 2 (Figure 5-19) show that tracer from the injection well reached both these monitoring wells but, no significant concentrations of tracer were observed in 16PM10-D, a deep downgradient monitoring well in this transect. Tracer concentrations in downgradient monitoring wells in Transects 3 and 4 were not high enough to evaluate the connectivity with the injection wells.

5.7.2.2 Results of Second Tracer Test

The results of the tracer test conducted between well 16EW12B (injection point) and well 16EW12B (extraction point) during the third cycle of electron donor amendment are summarized in Figure 5-21. Appendix H contains the results of monitoring during the test.

The monitoring results indicate travel times consistent with the results of the groundwater modeling of this recirculation scenario suggesting a travel time between recirculation wells (a distance of 35 feet) to be approximately one to two months. The travel time for the peak concentration (10% to 20% of the injected concentration) of tracer to wells IW-2 and IW-3, located 14 feet to the north and 14 feet to the south of 16EW12B, was about 9 to 10 days. The travel time for the peak concentration of tracer to well 16PM04 located 17.5 feet to the south of



Groundwater was recirculated from 21 Oct to 20 Dec

Well	IW3	IW2	PM4	IW4
Distance from Injection Well 16EW-12 in feet	14 North	14 South	17.5 South	21 South

Tracer Test #2 - Concentrations with Time (Nov - Dec 2005)
Site 16 Landfill, LHAAP, Karnack, Texas

Dec. 2008	Figure: **5-21**	Geosyntec consultants

16EW12B was approximately 15 days. The travel time for the peak concentration of tracer to well IW-4, located 21 feet to the south of 16EW12B, was approximately 28 days. The results of the second tracer test confirm the results of the groundwater modeling and suggest that electron donor can be distributed across the biobarrier.

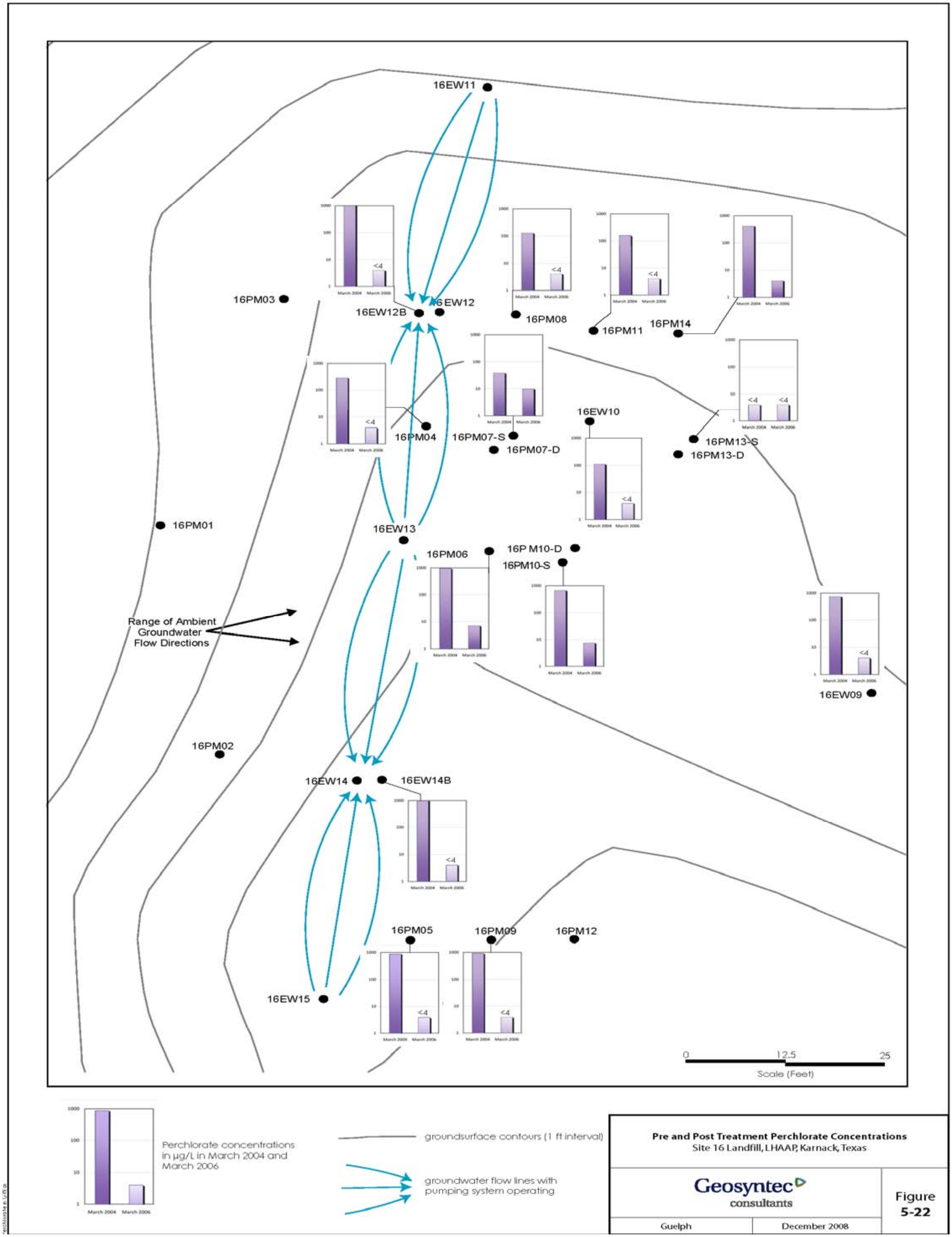
5.7.3 Results of Perchlorate Analysis

Figure 5-12 shows the perchlorate concentrations in groundwater samples collected during the baseline monitoring (Figure 5-12a), mid-demonstration monitoring (Figure 5-12b) and post-demonstration monitoring (Figure 5-12c). Figure 5-22 shows the relative concentration of perchlorate in monitoring wells downgradient of the biobarrier before addition of electron donor (March 2004) and post-demonstration (March 2006). Figures 5-23, 5-24, 5-25 and 5-26 show the perchlorate concentrations over time in Transects 1, 2, 3, and 4 respectively. Table 5-4 presents a summary of perchlorate and other key groundwater parameters collected during the main groundwater sampling events. Appendix F Table F-2 contains the results of all perchlorate analyses conducted during the demonstration and the results of a statistical analysis of the perchlorate data.

The groundwater monitoring data demonstrate that significant reductions in perchlorate concentrations were achieved across the line of recirculation wells in the semi-passive biobarrier (Figures 5-22). Following the third and final injection of electron donor, perchlorate concentrations were reduced to less that 4 μg/L in 10 of 13 shallow wells within and downgradient of the biobarrier and the concentrations in the other three wells ranged from 7 to 10 μg/L. Using half of the laboratory detection limit for groundwater samples where perchlorate was not detected, the average concentration of perchlorate in shallow wells within and downgradient of the biobarrier following the third addition of electron donor was 3.4 μg/L.

The concentrations of perchlorate were reduced substantially following the first and second injection of electron donor (Figure 5-12b) in transects 1, 2 and 3. The concentrations of perchlorate in Transect 4 were reduced from baseline concentrations, but less than optimal distribution of electron donor in this transect during the first and second addition of electron donor resulted in a lower reduction in perchlorate than was observed in the other transects. The concentrations of perchlorate in some of the monitoring wells located further downgradient of the biobarrier were not reduced to the same extent as in monitoring wells located closer to the biobarrier during monitoring in March 2005. This may be a result of perchlorate diffusing out of low hydraulic conductivity units downgradient of the biobarrier, or of poor hydraulic connectivity between the recirculation wells and the further downgradient monitoring wells, resulting in these wells receiving groundwater that passed beneath the biobarrier.

As discussed above, following the third electron donor delivery cycle, the concentrations of perchlorate were further reduced in all monitoring well transects, including Transect 4. The improved level of treatment of perchlorate is likely due to a combination of factors including: 1) the improved distribution of electron donor provided by the recirculation pattern used; 2) the residual beneficial impacts of the first and second electron donor delivery cycles including



Pre and Post Treatment Perchlorate Concentrations
Site 16 Landfill, LHAAP, Karnack, Texas

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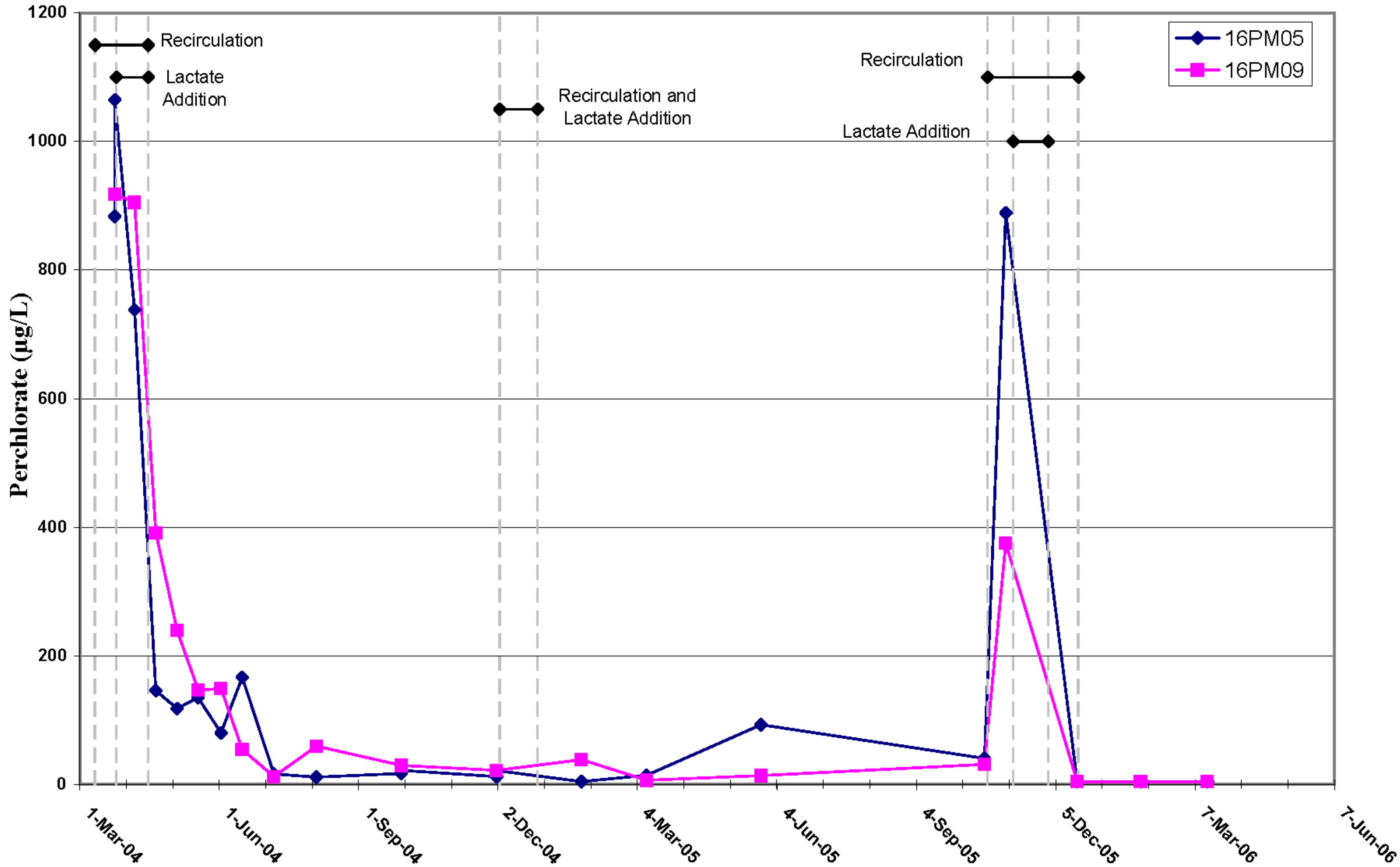
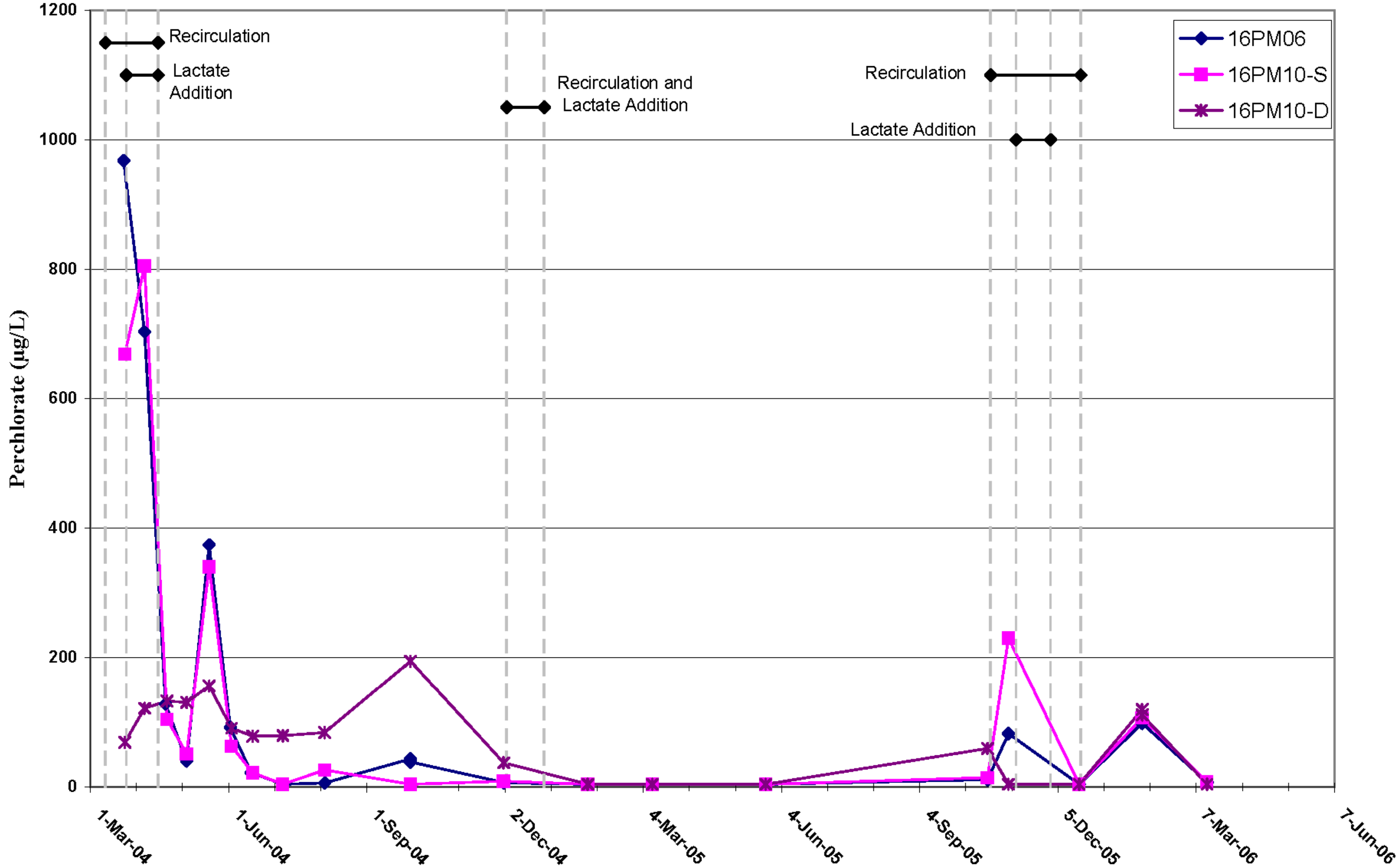
Guelph | December 2008

Figure 5-22

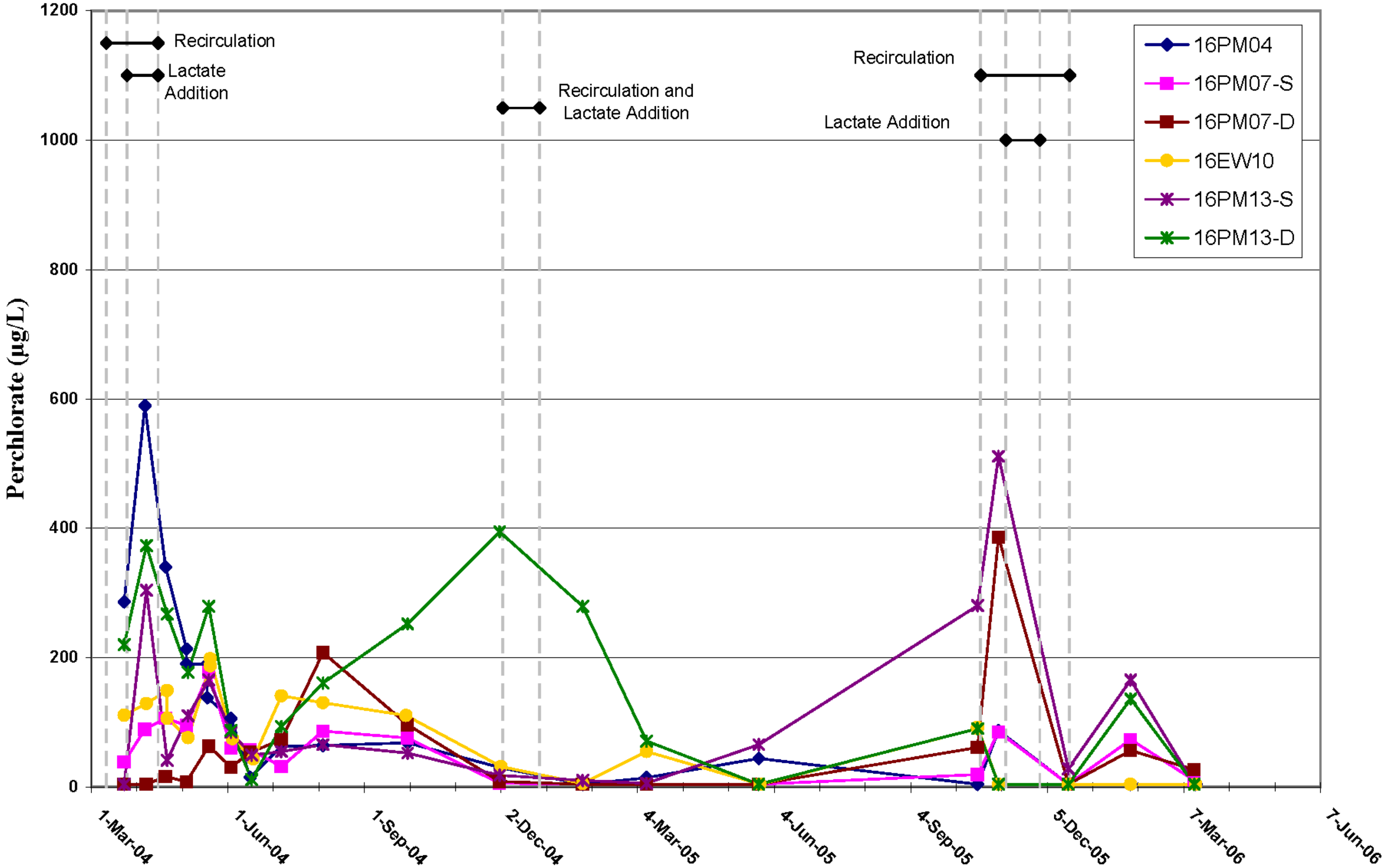


Perchlorate Concentrations with Time in Transect 1
Site 16 Landfill, LHAAP, Karnack, Texas

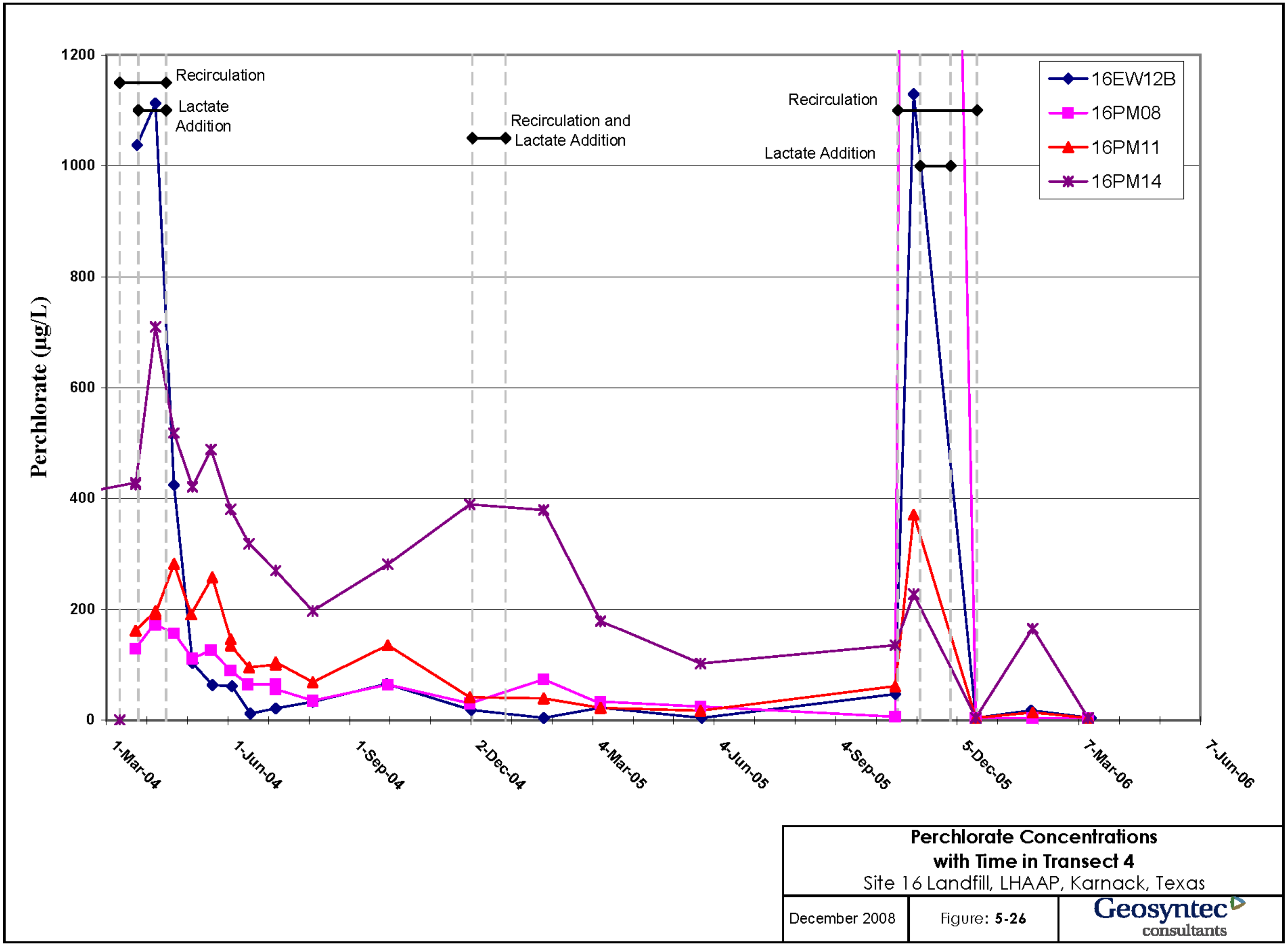
December 2008	Figure: **5-23**	Geosyntec consultants



Perchlorate Concentrations with Time in Transect 2 Site 16 Landfill, LHAAP, Karnack, Texas		
December 2008	Figure: **5-24**	Geosyntec consultants



Perchlorate Concentrations with Time in Transect 3 Site 16 Landfill, LHAAP, Karnack, Texas		
December 2008	Figure: **5-25**	Geosyntec consultants


1200
1000
800
600
400
200
0
Perchlorate (µg/L)
Recirculation
Lactate
Addition
Recirculation and
Lactate Addition
Recirculation
Lactate Addition
16EW12B
16PM08
16PM11
16PM14
1-Mar-04
1-Jun-04
1-Sep-04
2-Dec-04
4-Mar-05
4-Jun-05
4-Sep-05
5-Dec-05
7-Mar-06
7-Jun-06
Perchlorate Concentrations
with Time in Transect 4
Site 16 Landfill, LHAAP, Karnack, Texas
December 2008
Figure: 5-26
Geosyntec
consultants

reducing minerals in the geological media and growing biomass which can act as a long-term residual source of electron donor; and 3) the larger quantity of electron donor used during the third amendment cycle.

Concentrations of perchlorate in Transect 1 monitoring wells 16PM05 and 16PM09 (Figure 5-23) were in the range of 900 µg/L to 1,100 µg/L before the first electron donor delivery cycle. Following the initial amendment, the concentrations decreased rapidly (over about 1 month) to less that 200 µg/L and continued to decline over the following two months. Low concentrations of perchlorate were maintained through the beginning of December 2004 when the second amendment was conducted. The concentrations of perchlorate in wells 16PM05 and 16PM09 showed some variability following the second amendment but remained significantly below baseline concentrations. The concentrations of perchlorate increased significantly when the groundwater recirculation was initiated for the third electron donor delivery cycle and it is believed that high concentrations of perchlorate were drawn into the transect from the south. Following the third amendment, the elevated concentrations of perchlorate were quickly reduced and the concentrations in the 16PM05 and 16PM09 were less than 4 µg/L during the final three monitoring events. Data from monitoring well 16PM12 are not included on this Figure because of the apparent lack of hydraulic connection with the injection well (16EW15), as demonstrated by the results of the first tracer test.

Concentrations of perchlorate in Transect 2 monitoring wells 16PM06 and 16PM10-S (Figure 5-24) were in the range of 700 µg/L to 900 µg/L before the first electron donor delivery cycle. Following the initial amendment, the concentrations decreased over several months to less than 50 µg/L and continued to drop through December 2004 when the second amendment cycle was conducted. Following the second amendment in December 2004, perchlorate was not detected at wells 16PM06 and 16PM10-S for the next five months. The concentration of perchlorate in wells in this transect increased during recirculation of groundwater during the third amendment cycle and then decreased to less that 4 µg/L for two of the three final monitoring events.

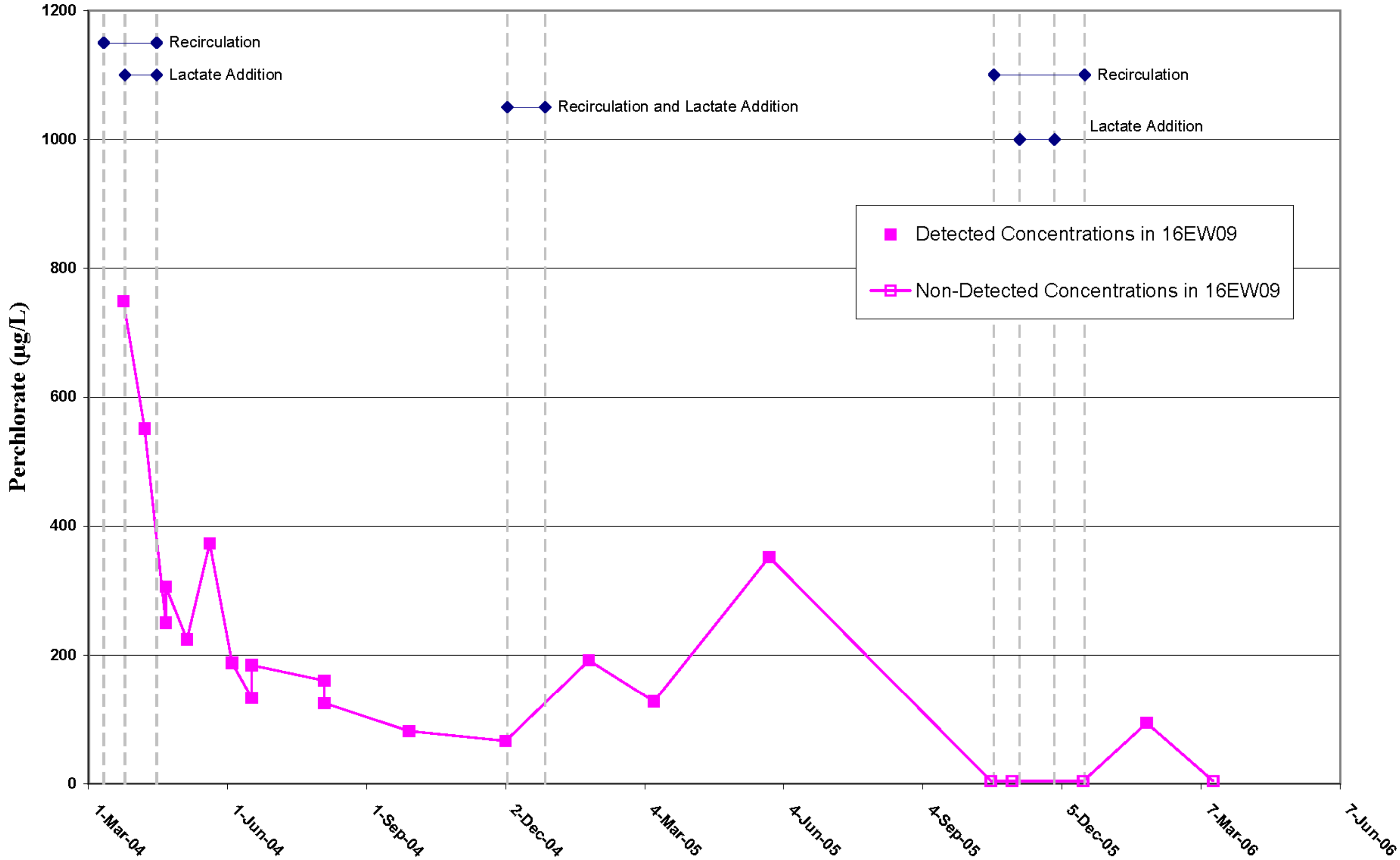
Concentrations of perchlorate in Transect 3 monitoring wells 16PM04, 16PM07-S, 16PM07-D, 16EW10, 16PM13-S and 16PM13-D (Figure 5-25) were in the range of 100 µg/L to 600 µg/L during the first electron donor delivery cycle. Following the initial amendment, the concentrations decreased for two months, then increased slightly for 3 months. The concentrations declined again in December 2004 before the second amendment cycle and, with the exception of 16EW10, remained low (less that 14 µg/L) during sampling in 2005. Data from the two deep monitoring wells 16PM07-D and 16PM13-D are included on this graph but have shown a slower response to the amendments, presumably because of the lesser degree of hydraulic connection between the biobarrier and deep monitoring wells as demonstrated in the results of the initial tracer test. The concentrations of perchlorate dropped following the second amendment cycle, but the concentrations rose again after 4 to 5 months. The concentration of perchlorate in wells in this transect increased during recirculation of groundwater for the third addition of electron donor then decreased significantly for two of the three final monitoring events.

Concentrations of perchlorate in Transect 4 monitoring wells 16EW12B, 16PM08 and 16PM11 are shown in Figure 5-26. The perchlorate concentration in the extraction well (16EW12B) was in the range of 1,000 μg/L to 1,100 μg/L before and during the initial electron donor delivery cycle. The concentrations in monitoring wells 16PM08 and 16PM11 were in the range of 100 μg/L to 200 μg/L before and during the initial amendment. Following the initial amendment, the concentration in 16EW12B decreased to less than 100 μg/L within a month. The perchlorate concentrations in samples from 16EW12B since June 2004 have been consistently less than 33 μg/L with the exception of one sample collected in September 2004 which was 65 μg/L. Although there was some reduction in concentrations in this transect following the first and second amendment cycles, the results achieved were not as low and as consistent as seen in the other transects. Transect 4 is located directly downgradient of extraction well 16EW12B and at the greatest distance from an electron donor injection well during the first and second amendment cycles compared to the other transects. It is believed that the amount of electron donor added in the vicinity of this transect, during the first and second amendments, was insufficient to achieve the target perchlorate concentration. The design of the semi-passive bio-barrier system allows for adjustment of the groundwater recirculation pattern to target areas where insufficient electron donor may have been added during initial injection cycles. During the third amendment cycle, the recirculation pattern was modified to provide additional electron donor to this transect. The concentration of perchlorate in this transect increased during recirculation of groundwater during the third amendment then the concentrations of perchlorate in 16EW12B, 16PM08 and 16PM11 all dropped significantly following the third amendment cycle. The concentrations of perchlorate in all the monitoring wells in this transect were below 4 μg/L during the post-demonstration monitoring event (March 2006).

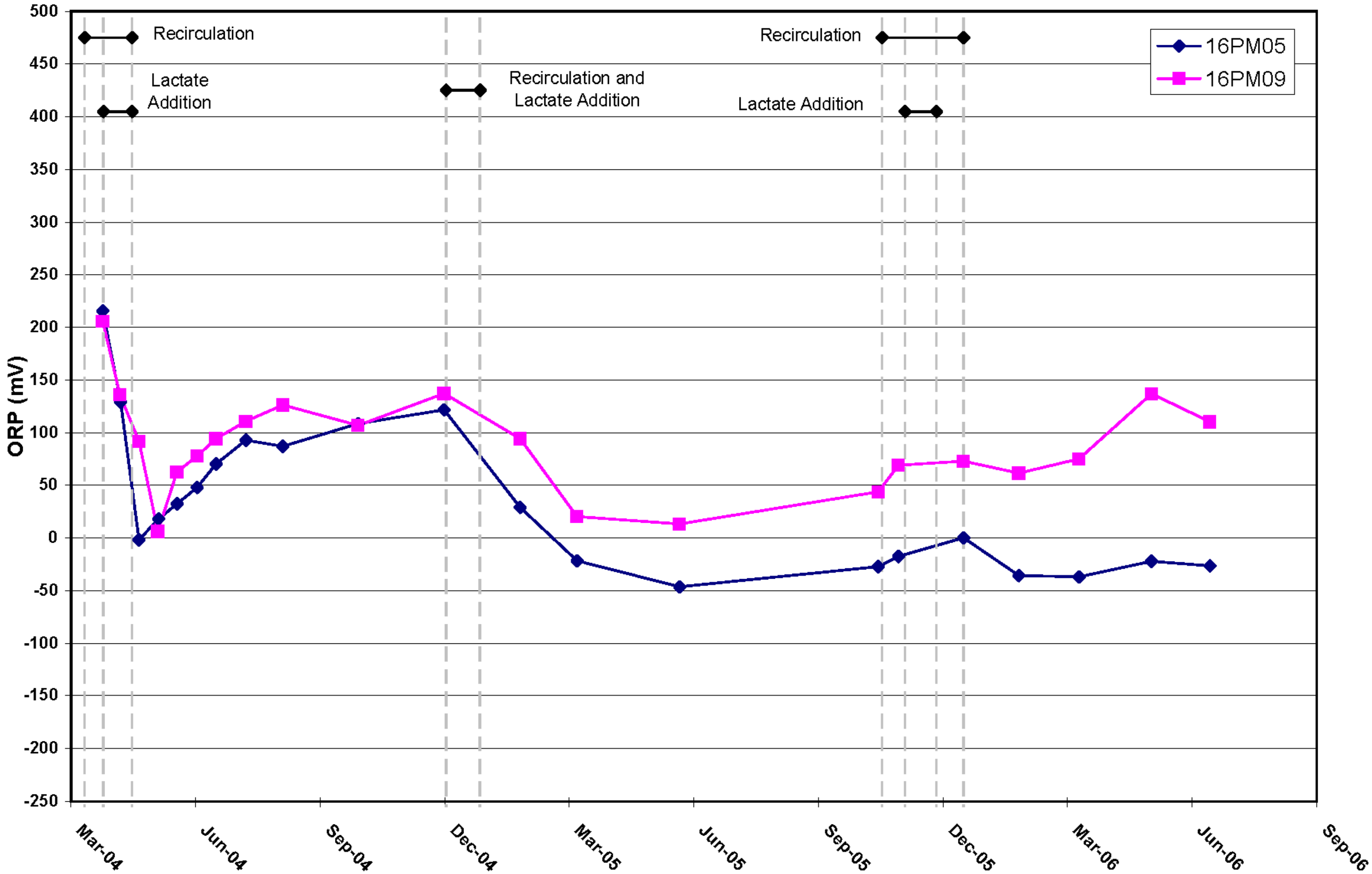
Concentrations of perchlorate over time in monitoring well 16EW09, located approximately 60 feet downgradient of the centerline of the recirculation wells, are shown in Figure 5-27. This well is located significantly downgradient of the biobarrier and monitors the downgradient impact of the biobarrier one groundwater. The baseline perchlorate concentration in this monitoring well was over 600 μg/L but declined significantly over the six months following the first electron donor delivery cycle. There was some increase in concentration of perchlorate during the first half of 2005 but declined at the end of 2005 and early 2006, such that 4 of the last 5 samples collected from this well were not detected.

5.7.4 Results of Oxidation-Reduction Potential (ORP) Monitoring

Figure 5-13 shows the ORP in samples from monitoring wells collected during baseline monitoring (Figure 5-13a), mid-demonstration monitoring (Figure 5-13b) and post demonstration monitoring (Figure 5-13c). Figures 5-28, 5-29, 5-30 and 5-31 show the ORP trends over time in Transects 1, 2, 3, and 4 respectively. Table 5-4 shows the ORP and concentrations of key groundwater parameters collected during the main groundwater sampling events. Appendix F contains tables with results of all laboratory and field measurements conducted during the demonstration test.



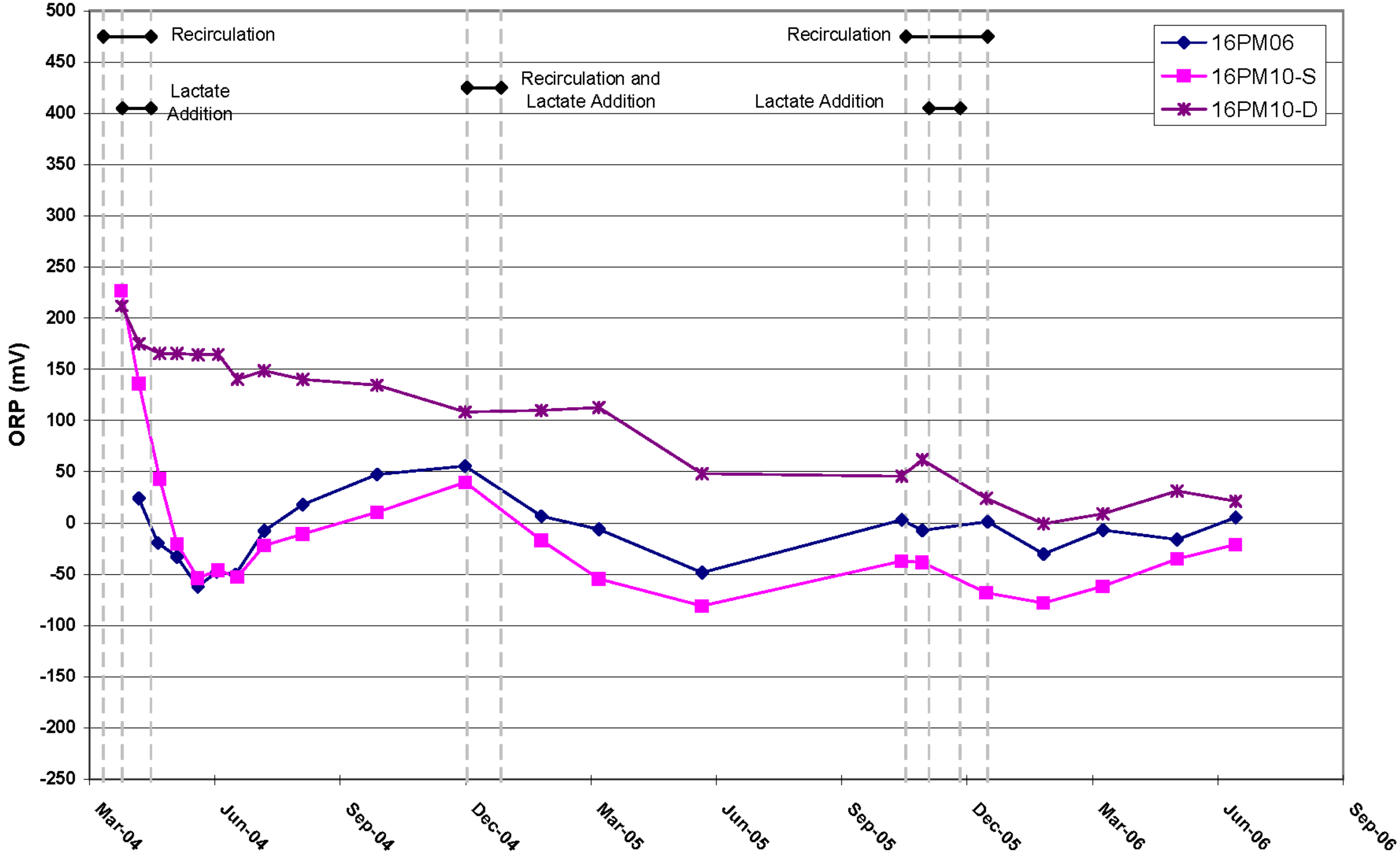
Perchlorate Concentrations with Time in 16EW09 Site 16 Landfill, LHAAP, Karnack, Texas		
December 2008	Figure: 5-27	Geosyntec consultants



ORP Trends in Transect 1

Site 16 Landfill, LHAAP, Karnack, Texas

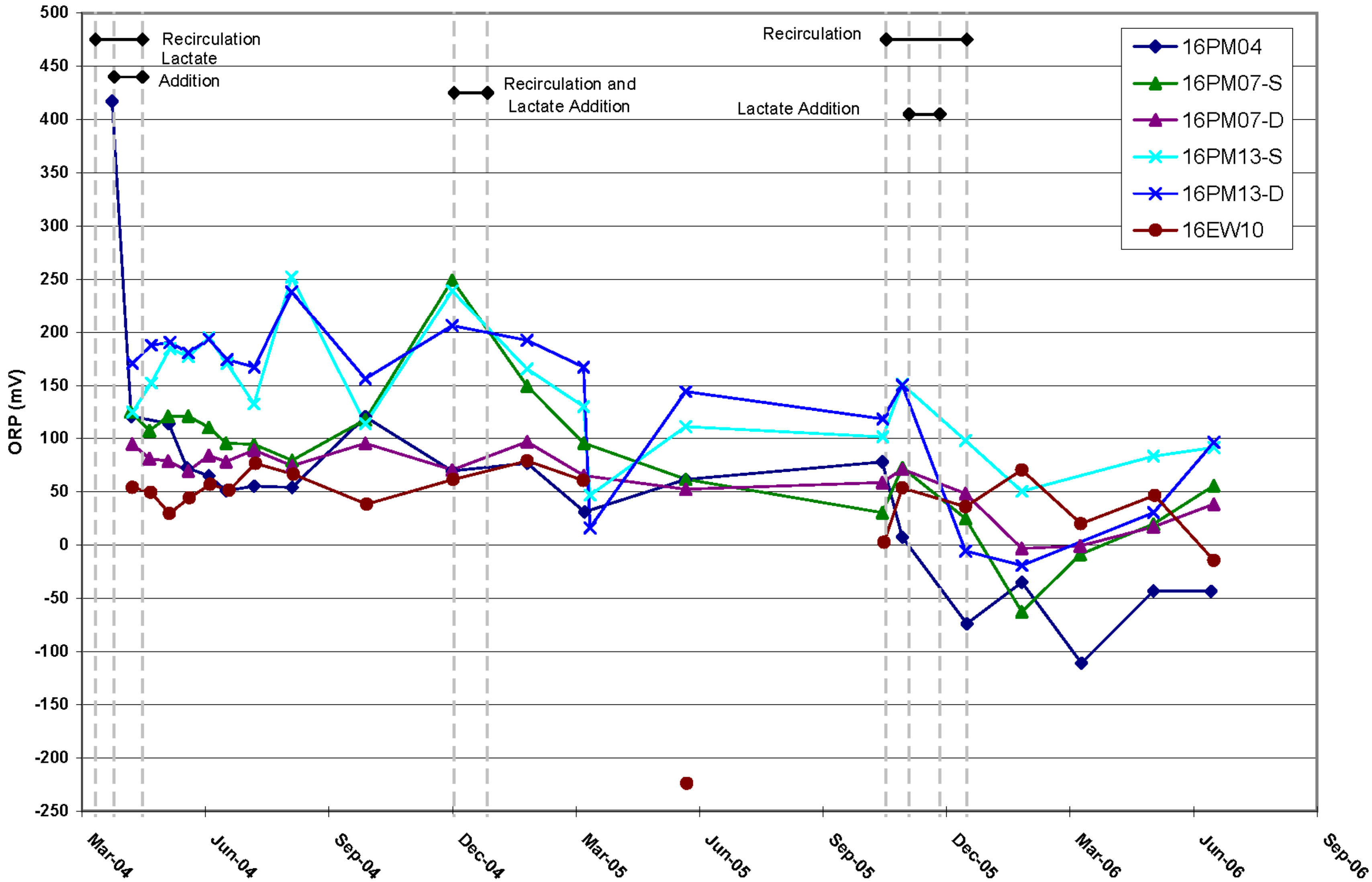
December 2008	Figure: **5-28**	Geosyntec consultants



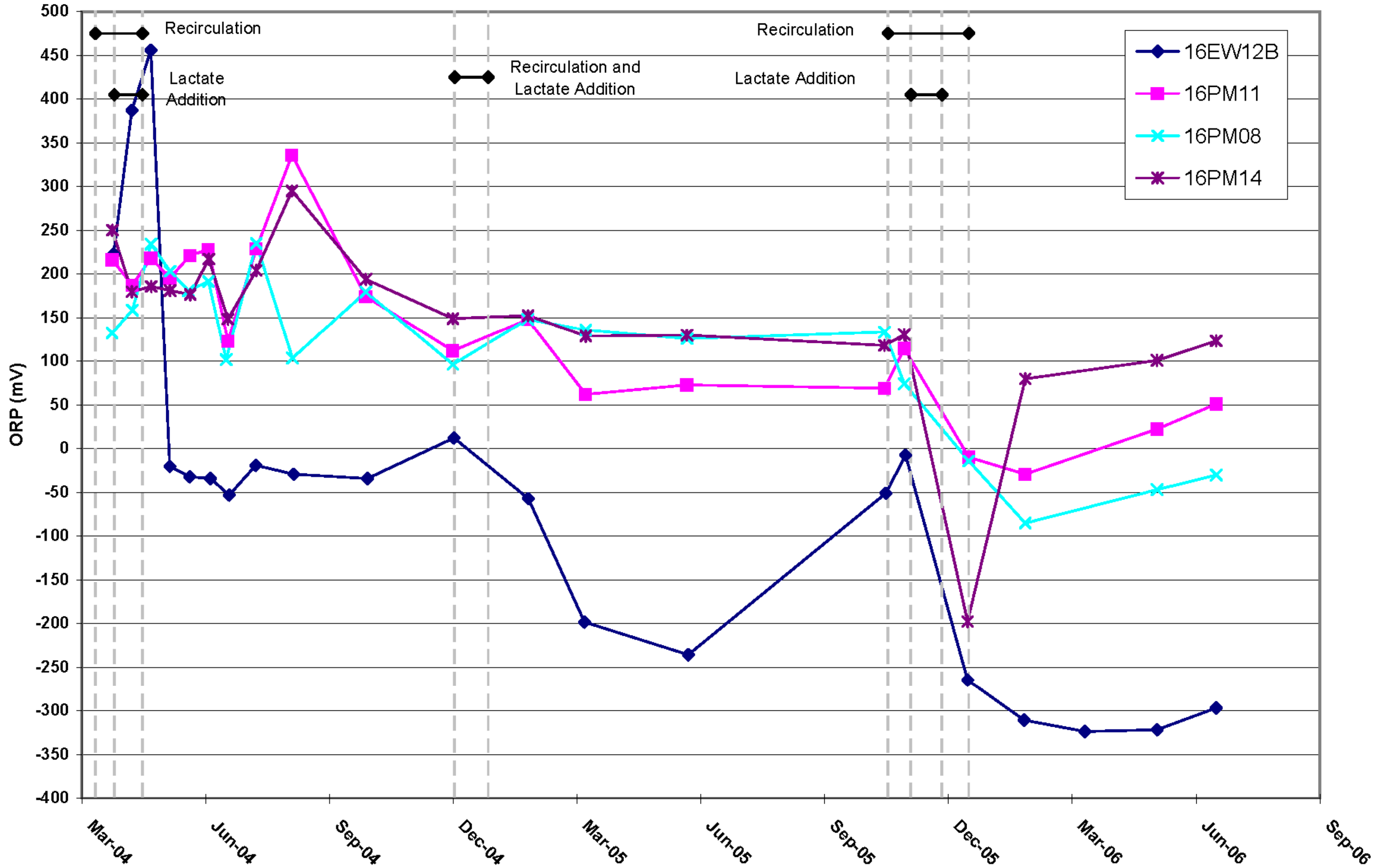
ORP Trends in Transect 2

Site 16 Landfill, LHAAP, Karnack, Texas

December 2008	Figure: **5-29**	Geosyntec consultants



ORP Trends in Transect 3		
Site 16 Landfill, LHAAP, Karnack, Texas		
December 2008	Figure: **5-30**	Geosyntec consultants



ORP Trends in Transect 4		
Site 16 Landfill, LHAAP, Karnack, Texas		
December 2008	Figure: 5-31	Geosyntec consultants

The ORP results in Transect 1 monitoring wells 16PM05 and 16PM09 (Figure 5-28) were in the range of 200 mV during the baseline sampling. During the first electron donor delivery cycle, the ORP decreased rapidly (over about 1 month) to about 0 mV then rose slowly over the next few months to a level of about 100 mV. The ORP remained at about 100 mV until after the second amendment cycle, where the ORP declined sharply to about -20 mV in 16PM05 and 20 mV in 16PM09 and the ORP remained low for a much longer period than following the first addition cycle (at least 9 to 10 months). Following the third electron donor cycle, the ORP in 16PM05 (well located closest to biobarrier) remained low while the ORP in 16PM09 increased slowly.

The ORP results in Transect 2 monitoring wells 16PM10-S and 16PM10-D (Figure 5-29) were in the range of 225 mV during the baseline sampling. The baseline ORP in well 16PM06 was about 25 mV. During the first electron donor delivery cycle, the ORP in 16PM06 and 16PM10-S decreased rapidly (over about 1 month) to about -50 mV and remained at this level for about 2.5 months. The ORP in these wells then rose gradually over the next five months to a level of about 50 mV in December 2004. Following the second amendment cycle, the ORP declined sharply to about -50 mV in 16PM10-S and -6 mV in 16PM06. The ORP in these wells remained low for a longer period time than following the first amendment cycle, but rose slightly prior to the third electron donor delivery cycle, and then subsequently declined again following the final electron donor addition cycle. The ORP in the deep monitoring well (16PM10-D) declined slowly after the first and second amendment periods and then more substantially following the third addition cycle.

The ORP results in Transect 3 monitoring well 16PM04 (Figure 5-30) were in the range of 400 mV during the baseline sampling event. ORP measurements were not obtained from the other monitoring wells in this transect prior to the initial electron donor delivery cycle, but wells in the vicinity of the transect (Figure 5-13a) ranged between 130 mV (16PM08) and 420 mV (16PM04). During the first electron donor delivery cycle, the ORP in 16PM04 decreased rapidly to about 125 mV then continued to decrease over the following 2 months, to about 50 mV. The ORP in 16PM04 then rose slowly over the next few months to a level of about 100 mV. Following the second amendment cycle, the ORP declined to about 30 mV. Following the first amendment cycle, the ORP in 16PM07-S declined slightly over the course of about four months. The ORP then rose the following four months to a maximum value of about 250 mV. Following the second amendment cycle, the ORP declined to less than 100 mV. The ORP in wells 16PM13S, 16PM13D and 16EW10 did not change significantly following the first amendment cycle and then dropped slightly following the second. The ORP in all the wells in this transect dropped more significantly following the third electron donor delivery cycle.

The ORP in Transect 4 extraction well 16EW12B (Figure 5-31) rose to 450 mV immediately following the first electron donor delivery cycle, although this high a value is not consistent with baseline ORP measurements in the vicinity of this well which were in the range of 200 to 250 mV. Shortly after the first amendment cycle the ORP dropped to about -25 mV and remained at that level until December 2004 when it increased slightly into the positive range (10 mV).

Following the second amendment cycle, the ORP declined to about -200 mV. Other monitoring wells in Transect 4 had baseline ORP generally in the range of 150 mV to 250 mV. Following the second amendment cycle, the ORP in 16PM11 and other wells in this transect declined slightly. Following the third amendment cycle, the ORP in all wells in this transect dropped significantly with the most significant and sustained declines in wells closest to the biobarrier.

5.7.5 Results of Volatile Fatty Acids Analysis

The results of volatile fatty acids (acetate, formic acid, lactic acid and propionate) analysis from samples collected from monitoring wells during the demonstration are provided in Appendix F, Table F-4. The concentrations of acetate at during the main groundwater sampling events are shown in Table 5-4. During the baseline sampling event, the concentrations of acetate in all wells were generally below the laboratory detection limit. As expected, following the initial amendment cycle, high concentrations of acetate generally correlated with a reduction in ORP and perchlorate concentrations. After the first and second amendment cycles, the highest concentrations of acetate (greater than 2,000 μmol/L) were observed in samples collected from wells 16EW12B and 16EW14B, which received a direct injection of electron donor at the end of the amendment period, and at well 16PM06 which is located immediately downgradient of recirculation well 16EW13. Elevated concentrations of acetate (greater than 200 μmol/L) were also observed in monitoring wells closest to the biobarrier which included: 16PM04, 16PM05 and 16PM10-S. As expected, lower concentrations of acetate were measured in samples further downgradient of the biobarrier. After the third amendment cycle, monitoring wells near the biobarrier which had not previously shown elevated concentrations following the first and second amendments showed very high concentrations of acetate (greater than 2,000 μmol/L).

5.7.6 Results of Sulfate Analysis

The results of sulfate (Appendix F, Table F-3) analysis indicated little change in concentrations at most monitoring wells (with the exception of 16EW12B, 16EW14B and 16PM06) following the first and second electron donor delivery cycles, suggesting that the semi-passive approach may be able to avoid undesirable groundwater impacts. This is in contrast to completely passive electron donor delivery approaches, which tend to promote complete sulfate reduction to sulfide, and in many cases methanogenesis. Some reduction in sulfate was observed in samples from 16EW12B and 16EW14B, which both received a direct injection of electron donor at the end of the amendment period, and at well 16PM06, located immediately downgradient of injection well 16EW13. These three wells had the highest measured concentrations of electron donor during the demonstration. The concentration of sulfate in 16EW12B was reduced from 2,730 mg/L before electron donor addition to about 1,000 mg/L. The concentration of sulfate in 16EW14B was reduced from 3,800 mg/L before electron donor addition to about 1,800 mg/L following the second addition of electron donor. The concentration of sulfate in 16PM06 was reduced from 3,800 mg/L before electron donor addition to about 1,800 mg/L following the second addition of electron donor. With the exception of three monitoring wells within or very close to the biobarrier, sulfate concentrations were not significantly reduced during the first and second

electron donor delivery and the impacts of the biobarrier on secondary water quality (such as producing sulfides from sulfate) appear to be minimal.

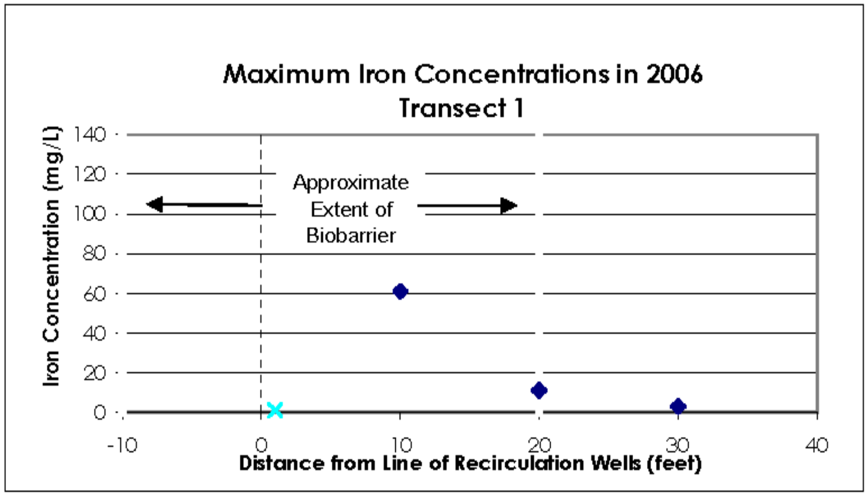
5.7.7 Results of Iron, Manganese and Arsenic Analysis

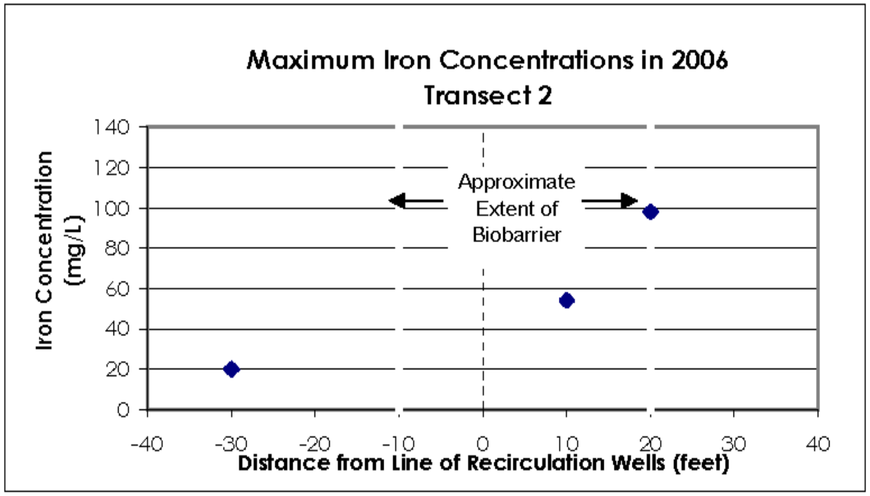
The post-demonstration groundwater results of the iron, manganese and arsenic analysis in monitoring wells along the four transects are summarized in Figures 5-32, 5-33 and 5-34 respectively. The figures show the iron, manganese and arsenic concentrations and the locations of the monitoring wells along each transect, relative to the biobarrier. The approximate extent of the biobarrier is shown extending 10 feet upgradient and 20 feet downgradient of the center line of the recirculation wells. Transects 2 and 4 have monitoring wells which are 30 feet and 20 feet respectively, upgradient of the biobarrier (16PM01 and 16PM03) and the concentrations of iron, manganese and arsenic in these wells remained low during the demonstration, which indicates they were outside the influence of the biobarrier.

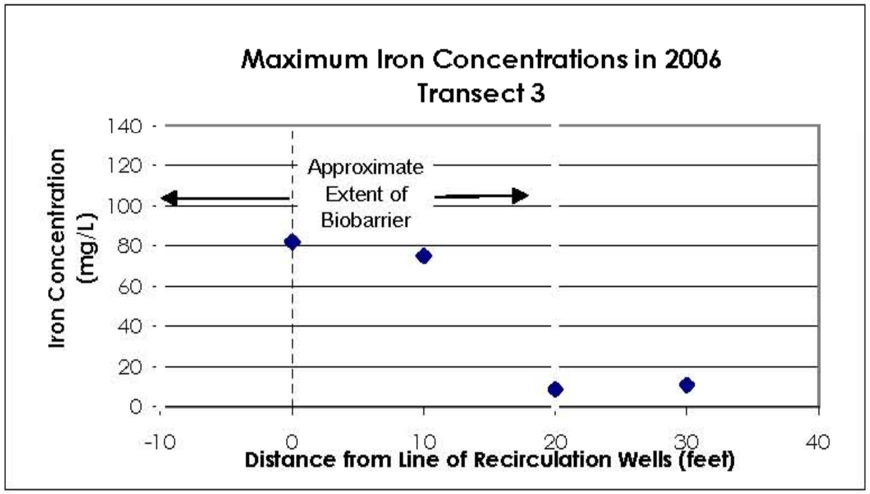
As shown in Figure 5-32, the concentrations of iron increased within the biobarrier relative to the upgradient well, but declined significantly downgradient of the biobarrier (i.e., 10 feet downgradient of biobarrier). Figure 5-33 shows a similar increase in manganese concentrations within the biobarrier relative to upgradient concentrations and a decline in concentrations downgradient of transect 1 and 4. The concentration of manganese in groundwater from the well 10 feet downgradient of the biobarrier in transect 3, however, remained elevated. Figure 5-34 shows the concentration of arsenic increasing within the biobarrier but as with the iron, the concentrations declined significantly 10 feet downgradient of the biobarrier.

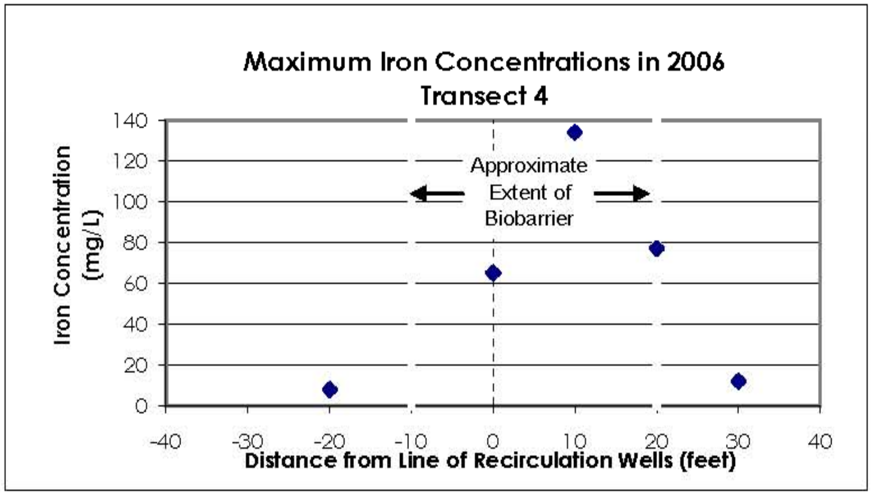
5.7.8 Groundwater Elevations

Post-demonstration groundwater elevations (Figure 5-35) show some regional change (i.e., lower overall levels in June 2006 relative to December 2003), but no significant change in elevation in wells in the vicinity of the biobarrier relative to one another that would indicate a significant impact on the hydraulics at the Site resulting from the addition of electron donor.









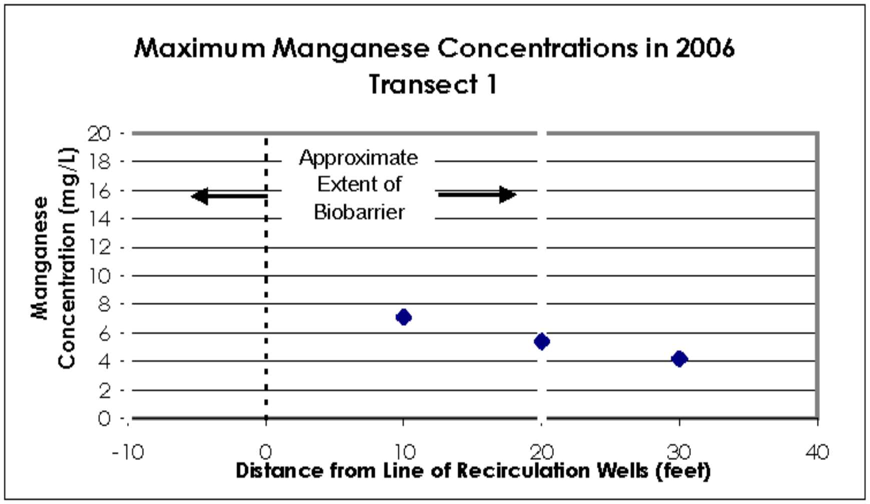
Notes:
Approximate extent of biobarrier is -10 feet to +20 feet from centerline of recirculation wells
Maximum concentrations in groundwater samples collected in sampling events in 2006
mg/L - milligrams per litre
------ center line of recirculation wells

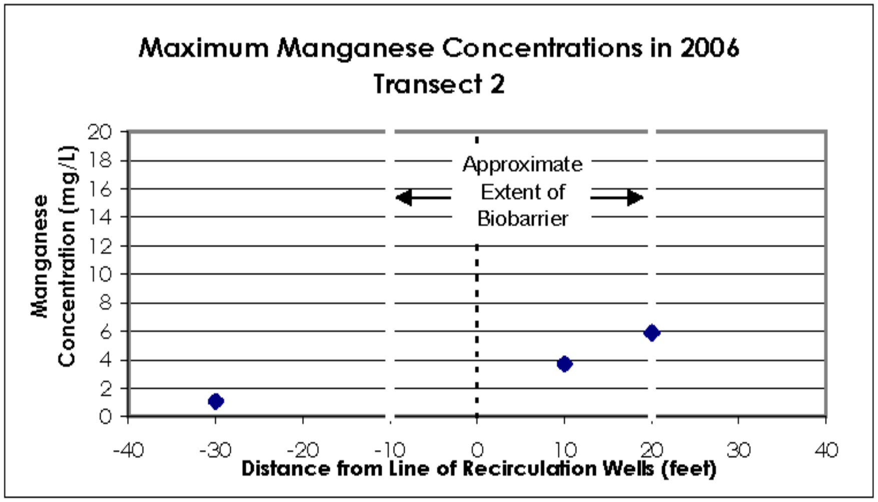
Post Treatment Iron Concentrations In Groundwater
Site 16 Landfill, LHAAP, Karnack, Texas

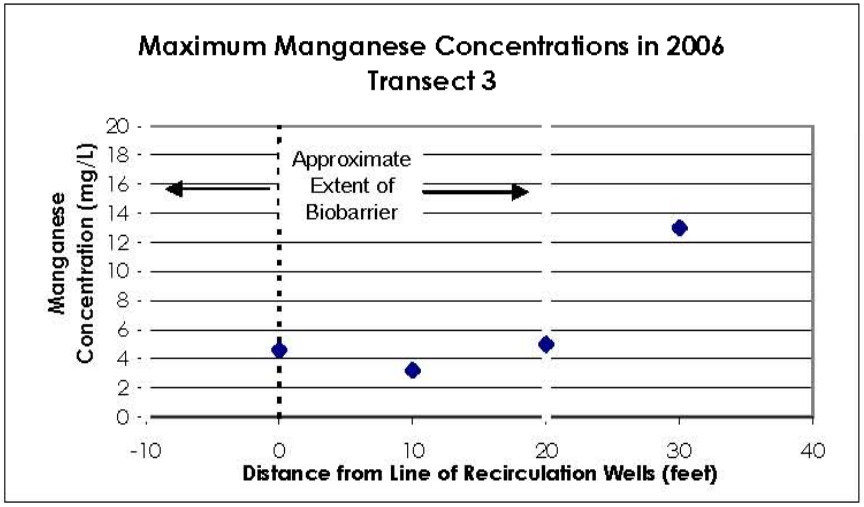
Geosyntec consultants

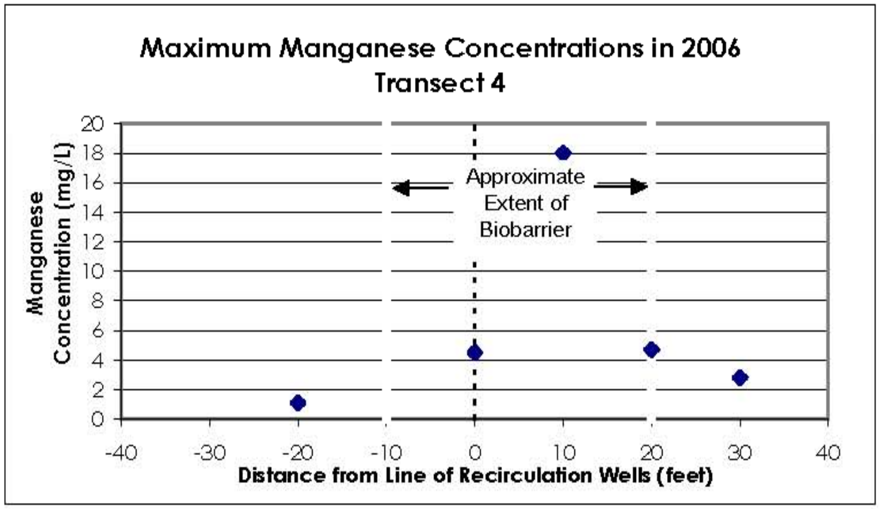
Figure **5-32**

Guelph | December 2008









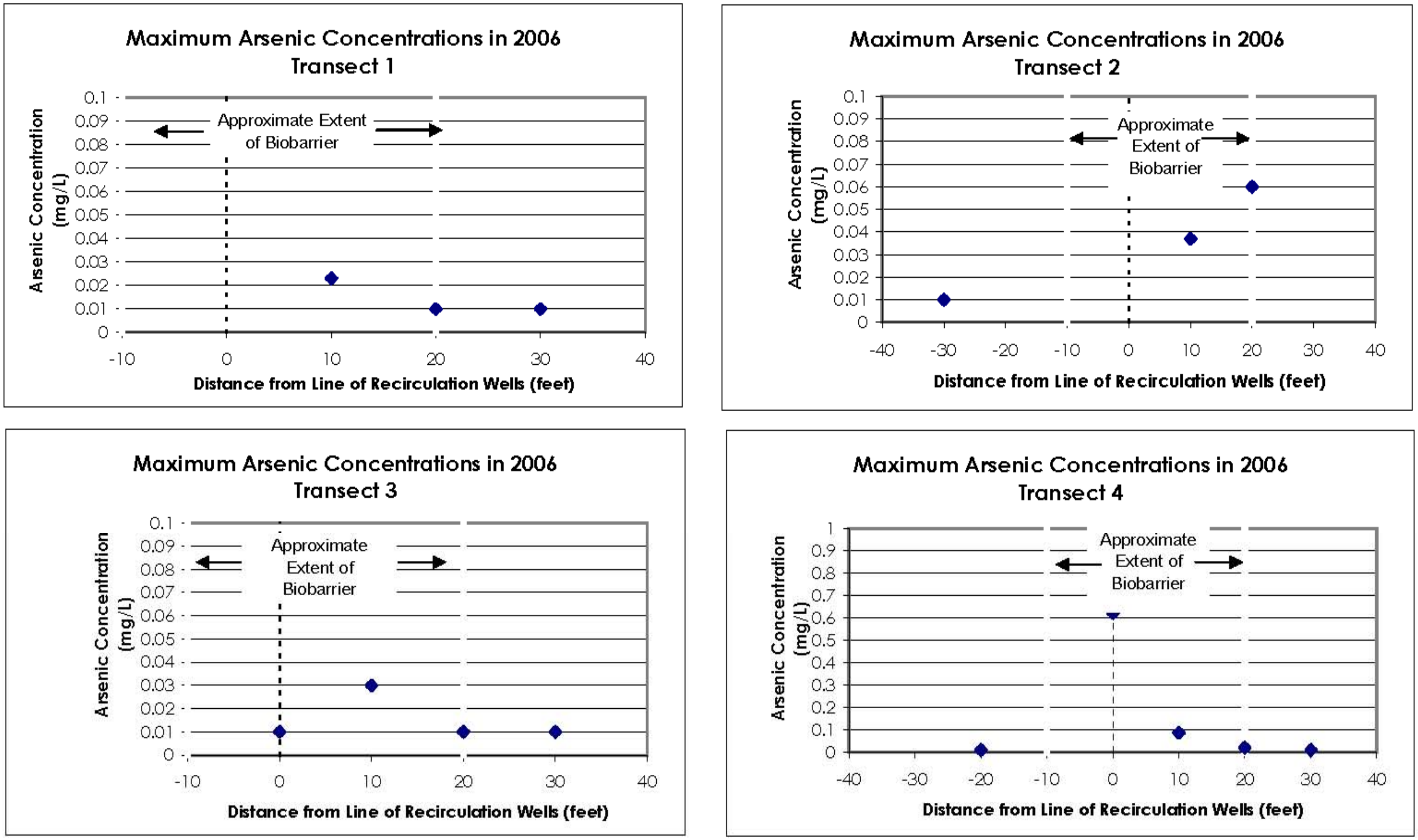
Notes:
Approximate extent of biobarrier is -10 feet to +20 feet from centerline of recirculation wells
Maximum concentrations in groundwater samples collected in sampling events in 2006
mg/L - milligrams per litre
------ center line of recirculation wells

Post Treatment Manganese Concentrations In Groundwater
Site 16 Landfill, LHAAP, Karnack, Texas

Geosyntec consultants

Guelph | December 2008

Figure **5-33**



Post Treatment Arsenic Concentrations In Groundwater

Site 16 Landfill, LHAAP, Karnack, Texas

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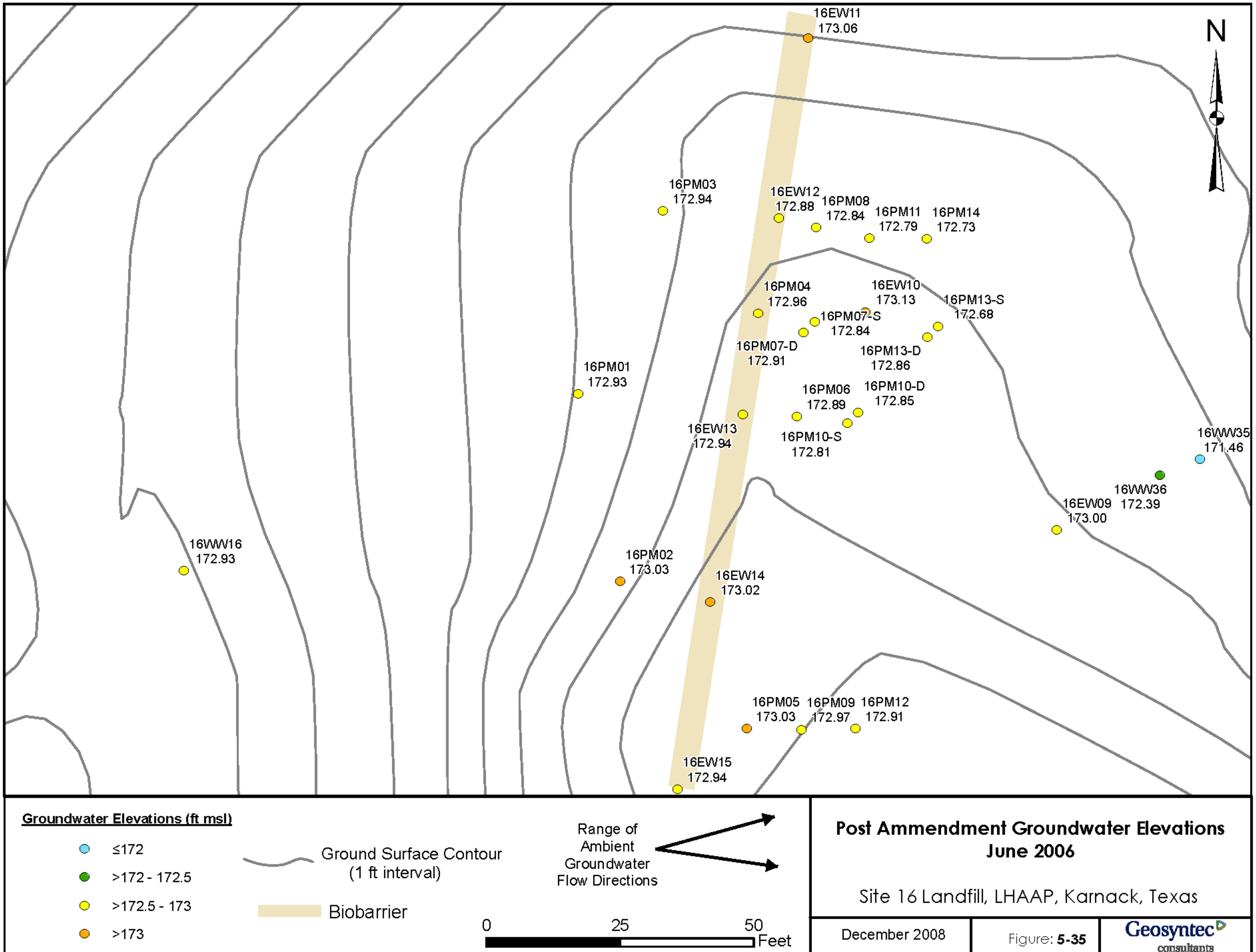
Guelph | December 2008

Figure **5-34**


N
16EW11
173.06
16PM03
172.94
16EW12
172.88
16PM08
172.84
16PM11
172.79
16PM14
172.73
16PM04
172.96
16EW10
173.13
16PM13-S
172.68
16PM07-S
172.84
16PM07-D
172.91
16PM13-D
172.86
16PM01
172.93
16PM06
172.89
16PM10-D
172.85
16EW13
172.94
16PM10-S
172.81
16WW35
171.46
16WW36
172.39
16EW09
173.00
16WW16
172.93
16PM02
173.03
16EW14
173.02
16PM05
173.03
16PM09
172.97
16PM12
172.91
16EW15
172.94
Groundwater Elevations (ft msl)
≤172
>172 - 172.5
>172.5 - 173
>173
Ground Surface Contour
(1 ft interval)
Biobarrier
Range of
Ambient
Groundwater
Flow Directions
0
25
50
Feet
Post Ammendment Groundwater Elevations
June 2006
Site 16 Landfill, LHAAP, Karnack, Texas
December 2008
Figure: 5-35
Geosyntec
consultants

6. PERFORMANCE ASSESSMENT

The performance objectives and results for this Demonstration are shown in Table 6-1 and are discussed below.

6.1 EASE OF INSTALLATION

The ease of installation of electron donor delivery components was evaluated based on the experience of field staff and the actual availability and costs of installed equipment. The success criterion for this objective is that the electron donor delivery system can be readily installed using standard industry procedures and contractors.

This objective was achieved based on experience with the actual installation of the electron donor delivery system at the LHAAP Site. The equipment required for the semi-passive injection of electron donor and short-term circulation of groundwater was all readily available through local drillers and plumbing suppliers. The procedures used to install the equipment were standard and well established procedures for local drillers and the procedures were simple enough to be conducted by field technicians with training in basic plumbing techniques.

6.2 EASE OF ELECTRON DONOR DELIVERY EVENTS

The ease of electron donor delivery events was evaluated based on the experience of field staff who conducted the actual electron donor events. The success criterion for this objective is that electron donor delivery events can be conducted by field staff with minimal training and effort.

This objective was achieved based on experience of field staff with the actual electron donor delivery events. The activities and procedures required for the electron donor delivery events were simple enough to be conducted by field staff with minimal specialized training and effort.

Electron donor was added to the groundwater recirculation injection wells and the intermediate injection points three times per week for a period of three weeks. Commercially available sodium lactate was used as the electron donor and this liquid was easy and safe to work. The procedure of transferring the electron donor from the drums to each of the injection locations took one person about one hour to complete three times per week.

The groundwater recirculation system was operated on a continuous basis over the three-week period of time when the electron donor was being added to the subsurface and there were no indications that significant fouling was occurring in the groundwater injection wells. The injection wells were equipped with a high level shut off switch to shut off the recirculation of groundwater if the water level in the injection wells rose indicating that the well was becoming fouled. The high level switch was not activated during any of the three electron donor injection events. It is believed that at least three factors contributed to the lack of significant fouling in the injection wells: 1) the use of soluble electron donor that could move quickly from the injection well without being held up on the soil particles; 2) the injection schedule (three times per week

rather than on a continuous basis) during the active injection phase which meant that microorganisms were not receiving a continuous supply of food even during the active phase of groundwater recirculation and injection; and 3) the fact that groundwater was not recirculated and electron donor was not added to the wells for a passive phase of at least eight months during which time biological material which may have accumulated in the well screen during the active phase would degrade significantly before the subsequent active phase.

6.3 ENHANCEMENT OF MICROBIOLOGICAL ACTIVITY

The enhancement of microbiological activity was evaluated using groundwater and soil analysis for geochemical parameters and microbial characterization. The success criterion for this objective is that electron donor addition enhances microbiological activity in the treatment zone.

This objective was achieved based on the results of chemical and geochemical characterization. Groundwater monitoring data for chemical and geochemical parameters demonstrated that electron donor addition enhanced microbiological activity in the treatment zone. Significant and sustained reductions in ORP were observed following addition of electron donor and provide the first indication that biological activity was enhanced by the addition of electron donor. A statistical analysis of ORP data was conducted (see Appendix F) and shows a high level of confidence that the injection of electron donor in the biobarrier resulted in significant reductions in ORP that are indicative of enhanced biological activity. The ORP values at each of three time periods following amendment with electron donor were evaluated with respect to the baseline OPR measurements. The P-Statistic for a T-Test for each time period after baseline sampling is less that 0.02 for all values and less that 0.006 for all wells after the third amendment of electron donor. The highest P-Statistics of 0.016 and 0.011 were calculated for the 16PM04 in the time periods following the 1st and 2nd amendment of electron donor. Monitoring well 16PM04 is located in Transect 3 where it was recognized that there was less than optimal distribution of electron donor during the 1st and 2nd amendment of electron donor. The P-Statistic for ORP data for this well following the 3rd amendment of electron donor was 0.0024 demonstrating a high level of confidence that the addition of electron donor reduced the ORP in the groundwater.

Reduction in sulfate in wells in the immediate vicinity of the electron donor injection points also indicates enhancement of biological activity. The reductions in perchlorate concentrations in groundwater observed following addition of electron donor provide additional indications that biological activity was enhanced by the addition of electron donor and that this biological activity included microorganisms capable of degradation of perchlorate.

TABLE 6-1: PERFORMANCE OBJECTIVES AND RESULTS
Site 16 Landfill, LHAAP, Karnack, Texas

Performance Objective	Data Requirement	Success Criteria	Results
Qualitative Performance Objectives			
1) Ease of Installation of Electron Donor Delivery Components	Experience of demonstration operators; actual availability and costs of installed equipment	Electron donor delivery system can be readily installed by standard industry procedures/contractors	Objective achieved - experience with system installation demonstrates that electron donor delivery system can be readily installed by standard industry procedures/contractors
2) Ease of Electron Donor Delivery Events	Experience of demonstration operators; and costs of events	Electron donor delivery events can be conducted with minimal training and effort	Objective achieved - Experience of operators demonstrates that electron donor delivery events can be conducted with minimal training and effort
3) Enhancement of Microbiological Activity	Groundwater and soil analyses for geochemical and microbial characterization	Electron donor addition enhances microbiological activity in the treatment zone	Objective achieved - Groundwater monitoring data demonstrates that electron donor addition enhances microbiological activity in the treatment zone
4) Ease of Performance Monitoring and Validation	Quality of data and ability to interpret and quantify biodegradation with confidence	Performance monitoring network allows straightforward data collection, interpretation and validation	Objective achieved - Quality of data and ability to interpret and quantify biodegradation with confidence demonstrates that performance monitoring network allows straightforward data collection, interpretation and validation
Quantitative Performance Objectives			
5) Reduction in Perchlorate Concentration	Groundwater sampling of performance monitoring wells	Perchlorate concentrations reduced to practical quantitation limit of 0.004 mg/L	Objective achieved - Groundwater sampling of performance monitoring wells demonstrates that the average perchlorate concentrations were reduced to below the practical quantitation limit of 4 µg/L
6) Radius of Influence and Distance for Degradation	Groundwater sampling of performance monitoring wells	Radius of influence for electron donor addition will extend between injection and extraction wells and perchlorate will be degraded before groundwater reaches the furthest downgradient performance monitoring wells.	Objective achieved - Groundwater sampling of performance monitoring wells during tracer test and following electron donor addition demonstrate that the radius of influence for electron donor addition extends between injection and extraction wells and perchlorate was degraded before groundwater reaches downgradient performance monitoring wells

Notes:

µg/L - micrograms per Liter

6.4 EASE OF PERFORMANCE MONITORING AND VALIDATION

The ease of performance monitoring and validation was evaluated based on the quality of the data obtained and the ability to interpret and quantify biodegradation with confidence. The success criterion for this objective is that the performance monitoring network and sampling conducted allows for straightforward data collection, interpretation and validation.

This objective was achieved based on the data obtained during the demonstration. The quality of the data obtained and the ability to interpret this data and quantify biological activity (by the reduction in ORP) with confidence and reduction in perchlorate demonstrated that the performance monitoring network allowed for straightforward data collection, interpretation and validation.

The monitoring well network installed for the demonstration was extensive and allowed the collection of groundwater samples for measurement of field parameters and for chemical analysis from key locations in the demonstration test area. Monitoring points along four distinct transects parallel to the ambient direction of groundwater flow allowed for an assessment of groundwater quality within and downgradient of the biobarrier. The monitoring well network also included multiple sampling locations along the alignment of the recirculation wells used to create the biobarrier that were used to characterize the groundwater quality along the biobarrier and to monitor the distribution of tracer during the tracer testing conducted at the time of the 1st and 3rd electron donor amendment phase.

Measurement of field parameters and analysis of samples collected from monitoring wells allowed for data to be collected which demonstrated significant reductions in ORP associated with the enhancement of biological activity resulting from the addition of electron donor. The reduction in ORP in samples from monitoring wells in the demonstration area provided a quantitative measure of the biological activity in the subsurface. The monitoring well network allowed for the collection of data that showed the reduction in perchlorate concentrations to validate the performance of the technology.

6.5 REDUCTION IN PERCHLORATE CONCENTRATION

The reduction in perchlorate concentrations was evaluated based on groundwater sampling of performance monitoring wells. The success criterion for this objective is that perchlorate concentrations are reduced to the practical quantitation limit of 4 μg/L.

This objective was achieved based on groundwater sampling of performance monitoring wells that demonstrated that the average perchlorate concentrations were reduced to below the PQL of 4 μg/L during the final sampling event. The objective of 4 μg/L was not achieved in all samples at all time periods as discussed below.

Figure 5-12 shows the perchlorate concentrations in groundwater samples collected during the baseline monitoring (Figure 5-12a), mid-demonstration monitoring (Figure 5-12b) and post-demonstration monitoring (Figure 5-12c). Figure 5-22 shows the relative concentration of perchlorate in monitoring wells downgradient of the biobarrier before addition of electron donor (March 2004) and post-demonstration (March 2006). Figures 5-23, 5-24, 5-25 and 5-26 show the perchlorate concentrations over time in Transects 1, 2, 3, and 4 respectively. Table 5-4 presents a summary of perchlorate and other key groundwater parameters collected during the main groundwater sampling events. Appendix F Table F-2 contains the results of all perchlorate analyses conducted during the demonstration and the appendix also contains the results of a statistical analysis of the perchlorate data.

The groundwater monitoring data demonstrate that significant reductions in perchlorate concentrations were achieved across the line of recirculation wells in the semi-passive biobarrier (Figures 5-22). Following the third and final injection of electron donor, perchlorate concentrations were reduced to less that 4 μg/L in 10 of 13 shallow wells within and downgradient of the biobarrier and the concentrations in the other three wells ranged from 7 to 10 μg/L. Using half of the laboratory detection limit for groundwater samples where perchlorate was not detected, the average concentration of perchlorate in shallow wells within and downgradient of the biobarrier following the third addition of electron donor was 3.4 μg/L.

The concentrations of perchlorate were reduced substantially following the first and second injection of electron donor (Figure 5-12b) in transects 1, 2, and 3. The concentrations of perchlorate in Transect 4 were reduced from baseline concentrations, but less than optimal distribution of electron donor in this transect during the first and second addition of electron donor resulted in a lower reduction in perchlorate than was observed in the other transects. The concentrations of perchlorate in some of the monitoring wells located further downgradient of the biobarrier were not reduced to the same extent as in monitoring wells located closer to the biobarrier during monitoring in March 2005. This may be a result of perchlorate diffusing out of low hydraulic conductivity units downgradient of the biobarrier, or of poor hydraulic connectivity between the recirculation wells and the further downgradient monitoring wells, resulting in these wells receiving groundwater that passed beneath the biobarrier.

As discussed above, following the third electron donor delivery cycle, the concentrations of perchlorate were further reduced in all monitoring well transects, including Transect 4. The improved level of treatment of perchlorate is likely due to a combination of factors including: 1) the improved distribution of electron donor provided by the recirculation pattern used; 2) the residual beneficial impacts of the first and second electron donor delivery cycles including reducing minerals in the geological media and growing biomass which can act as a long-term residual source of electron donor; and 3) the larger quantity of electron donor used during the third amendment cycle.

Concentrations of perchlorate in Transect 1 monitoring wells 16PM05 and 16PM09 (Figure 5-23) were in the range of 900 μg/L to 1,100 μg/L before the first electron donor delivery cycle.

Following the initial amendment, the concentrations decreased rapidly (over about 1 month) to less that 200 μg/L and continued to decline over the following two months. Low concentrations of perchlorate were maintained through the beginning of December 2004 when the second amendment was conducted. The concentrations of perchlorate in wells 16PM05 and 16PM09 showed some variability following the second amendment but remained significantly below baseline concentrations. The concentrations of perchlorate increased significantly when the groundwater recirculation was initiated for the third electron donor delivery cycle and it is believed that high concentrations of perchlorate were drawn into the transect from the south. Following the third amendment, the elevated concentrations of perchlorate were quickly reduced and the concentrations in the 16PM05 and 16PM09 were less than 4 μg/L during the final three monitoring events. Data from monitoring well 16PM12 are not included on this Figure because of the apparent lack of hydraulic connection with the injection well (16EW15), as demonstrated by the results of the first tracer test.

Concentrations of perchlorate in Transect 2 monitoring wells 16PM06 and 16PM10-S (Figure 5-24) were in the range of 700 μg/L to 900 μg/L before the first electron donor delivery cycle. Following the initial amendment, the concentrations decreased over several months to less than 50 μg/L and continued to drop through December 2004 when the second amendment cycle was conducted. Following the second amendment in December 2004, perchlorate was not detected at wells 16PM06 and 16PM10-S for the next five months. The concentration of perchlorate in wells in this transect increased during recirculation of groundwater during the third amendment cycle and then decreased to less that 4 μg/L for two of the three final monitoring events.

Concentrations of perchlorate in Transect 3 monitoring wells 16PM04, 16PM07-S, 16PM07-D, 16EW10, 16PM13-S and 16PM13-D (Figure 5-25) were in the range of 100 μg/L to 600 μg/L during the first electron donor delivery cycle. Following the initial amendment, the concentrations decreased for two months, then increased slightly for 3 months. The concentrations declined again in December 2004 before the second amendment cycle and, with the exception of 16EW10, remained low (less that 14 μg/L) during sampling in 2005. Data from the two deep monitoring wells 16PM07-D and 16PM13-D are included on this graph but have shown a slower response to the amendments, presumably because of the lesser degree of hydraulic connection between the biobarrier and deep monitoring wells as demonstrated in the results of the initial tracer test. The concentrations of perchlorate dropped following the second amendment cycle, but the concentrations rose again after 4 to 5 months. The concentration of perchlorate in wells in this transect increased during recirculation of groundwater for the third addition of electron donor then decreased significantly for two of the three final monitoring events.

Concentrations of perchlorate in Transect 4 monitoring wells 16EW12B, 16PM08 and 16PM11 are shown in Figure 5-26. The perchlorate concentration in the extraction well (16EW12B) was in the range of 1,000 μg/L to 1,100 μg/L before and during the initial electron donor delivery cycle. The concentrations in monitoring wells 16PM08 and 16PM11 were in the range of 100 μg/L to 200 μg/L before and during the initial amendment. Following the initial amendment, the

concentration in 16EW12B decreased to less than 100 μg/L within a month. The perchlorate concentrations in samples from 16EW12B since June 2004 have been consistently less than 33 μg/L with the exception of one sample collected in September 2004 that was 65 μg/L. Although there was some reduction in concentrations in this transect following the first and second amendment cycles, the results achieved were not as low and as consistent as seen in the other transects. Transect 4 is located directly downgradient of extraction well 16EW12B and at the greatest distance from an electron donor injection well during the first and second amendment cycles compared to the other transects. It is believed that the amount of electron donor added in the vicinity of this transect, during the first and second amendments, was insufficient to achieve the target perchlorate concentration. The design of the semi-passive bio-barrier system allows for adjustment of the groundwater recirculation pattern to target areas where insufficient electron donor may have been added during initial injection cycles. During the third amendment cycle, the recirculation pattern was modified to provide additional electron donor to this transect. The concentration of perchlorate in this transect increased during recirculation of groundwater during the third amendment then the concentrations of perchlorate in 16EW12B, 16PM08 and 16PM11 all dropped significantly following the third amendment cycle. The concentrations of perchlorate in all the monitoring wells in this transect were below 4 μg/L during the post-demonstration monitoring event (March 2006).

Concentrations of perchlorate over time in monitoring well 16EW09, located approximately 60 feet downgradient of the centerline of the recirculation wells, are shown in Figure 5-27. This well is located significantly downgradient of the biobarrier and monitors the downgradient impact of the biobarrier one groundwater. The baseline perchlorate concentration in this monitoring well was over 600 μg/L but declined significantly over the six months following the first electron donor delivery cycle. There was some increase in concentration of perchlorate during the first half of 2005 but declined at the end of 2005 and early 2006, such that 4 of the last 5 samples collected from this well were not detected.

6.6 RADIUS OF INFLUENCE AND DISTANCE FOR DEGRADATION

The radius of influence and distance for degradation was evaluated based on the results of groundwater sample collected from the performance monitoring wells. The success criterion for this objective is that the radius of influence for electron donor addition will extend between recirculation wells and that perchlorate will be degraded before groundwater reaches the furthest downgradient performance monitoring well.

This objective was achieved based on groundwater sample results from performance monitoring wells during the tracer tests and following electron donor delivery cycles which demonstrated that the radius of influence for electron donor extends between all recirculation wells and that perchlorate was degraded before groundwater reached downgradient performance monitoring wells.

A summary of the results of the first tracer test is shown in Figures 5-14, 5-15, 5-16 and 5-17. The figures show the tracer concentrations (either bromide or iodide) in wells along the four

recirculation segments. Table 5-6 includes a summary of the tracer recoveries, travel times and results of the mass balance for each segment. During this tracer test groundwater was extracted from 16EW12B and 16EW14B at rates of 1.0 gpm and 1.7 gpm respectively and groundwater was injected into 16EW11, 16EW13 and 16EW15 at rates of 1.0 gallon per minute (gpm), 0.85 gpm and 0.85 gpm respectively. The tracer concentrations and mass balance for intermediate wells in Segments 1, 2 and 4 show consistent movement of the tracer within each segment. The travel time between the injection wells and first intermediate injection well (located 15 feet from the injection well) was typically one to two weeks. The mass balance estimates between the injection wells and the first intermediate wells in Segments 1, 2 and 4 ranged between 57% and 100%. The tracer concentrations and mass balance in intermediate wells in Segment 3 indicate significantly slower movement of the tracer. The slower movement of tracer is consistent with the groundwater flow model that showed some of the water injected into EW-13 being pulled back towards the south into the higher pumping 16EW14B because 16EW12B could not sustain as high a yield.

The results of the second tracer test conducted during the 3rd injection of electron donor between well 16EW12B (injection point) and well 16EW12B (extraction point) are summarized in Figure 5-21. During this tracer test groundwater was extracted from 16EW14B at a rate of 1.7 gpm and injected into 16EW12B at rate of 1.7 gpm. The monitoring results indicate travel times consistent with the results of the groundwater modeling of this recirculation scenario suggesting a travel time between recirculation wells (a distance of 35 feet) to be approximately one to two months. The travel time for the peak concentration (10% to 20% of the injected concentration) of tracer to wells IW-2 and IW-3, located 14 feet to the north and 14 feet to the south of 16EW12B, was about 9 to 10 days. The travel time for the peak concentration of tracer to well 16PM04 located 17.5 feet to the south of 16EW12B was approximately 15 days. The travel time for the peak concentration of tracer to well IW-4, located 21 feet to the south of 16EW12B, was approximately 28 days. The results of the second tracer test confirm the results of the groundwater modeling and suggest that electron donor can be distributed across the biobarrier.

The distance for degradation was demonstrated by the reductions in perchlorate in monitoring wells in the immediate vicinity of the biobarrier alignment. Degradation of perchlorate occurred in wells very close to the alignment of the biobarrier indicating that the degradation of perchlorate can occur within the distance that electron donor is distributed upgradient of the center of the alignment of the biobarrier.

7. COST ASSESSMENT

This section presents the results of a cost assessment to implement EISB for perchlorate impacted groundwater using the semi-passive approach for the addition of electron donor. Section 7.1 describes a costing model that was developed for the application of EISB with a comparison to a pump and treat system, Section 7.2 presents an assessment of the cost drivers for the application of the technology, and Section 7.3 presents the results of an analysis of the costing model.

The semi-passive EISB approach for treatment of perchlorate impacted groundwater can integrate the best aspects of both the active approach (fewer injection locations and less impact on secondary water quality characteristics) and the passive approach (lower o&m and minimal permanent *Ex Situ*), in order to optimize the balance of capital and o&m costs.

7.1 COST MODEL

A cost model was developed for EISB for this report and a book being prepared on different approaches to EISB for perchlorate impacted groundwater. The cost model described below is limited the semi-passive approach with a comparison of costs to a conventional pump and treat system in similar site conditions.

The cost model was developed for a template site based on a typical site with perchlorate impacted shallow groundwater. The specific site characteristics used are presented in Table 7-1 and an illustration of the plume and biobarrier are provided in Figure 7-1. Using these site conditions, the cost model identifies the major cost drivers for the semi-passive approach and provides an estimate of costs for the capital, o&m, and long-term monitoring. Capital costs included design and permitting activities, mobilization, site preparation, well installation, chemical reagents, management, and derived waste disposal. o&m costs included mobilization, equipment replacement and supplies (e.g., electron donor). Long-term monitoring costs included field supplies, sampling equipment, laboratory analysis and regulatory reporting. Labor associated with the planning, procurement and implementation of all aspects of the semi-passive EISB approach is also included.

A cost estimate was also prepared for a conventional pump and treat system to provide a point of comparison with the semi-passive EISB approach.

The cost model focused on treatment of a contaminated plume of groundwater. Specifically excluded from consideration are the costs of pre-remediation investigations (e.g., plume delineation, risk determination, and related needs), treatability studies, source zone treatment, and post remediation and decommissioning.

This analysis is focused on treatment of a contaminated plume of groundwater and costs for possible source zone treatment are not included. In reality, it may be appropriate to treat source

TABLE 7-1: SITE CHARACTERISTICS AND DESIGN PARAMETERS FOR EISB OF PERCHLORATE IMPACTED GROUNDWATER
Site 16 Landfill, LHAAP, Karnack, Texas

		Scenario / Case Description and Number												
Design Parameter	**units**	**Base Case**	**Accelerated Clean Up Case**	**Low Perchlorate Conc. Case**	**High Perchlorate Conc. Case**	**Low Donor Demand Case**	**High Donor Demand Case**	**Low GW Velocity Case**	**High GW Velocity Case**	**Deep GW Case**	**Thin Interval Case**	**Thick Interval Case**	**Narrow Plume Case**	**Wide Plume Case**
		Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9	Case 10	Case 11	Case 12	Case 13
Width of Plume	meters	120	120	120	120	120	120	120	120	120	120	120	30	240
	feet	400	400	400	400	400	400	400	400	400	400	400	100	800
Length of Plume	meters	240	240	240	240	240	240	240	240	240	240	240	240	240
	feet	800	800	800	800	800	800	800	800	800	800	800	800	800
Porosity		0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Gradient		0.008	0.008	0.008	0.008	0.008	0.008	0.0008	0.016	0.008	0.008	0.008	0.008	0.008
Hydraulic Conductivity*	cm/sec	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Upgradient Perchlorate Concentration	mg/L	2	2	0.4	10	2	2	2	2	2	2	2	2	2
Downgradient Perchlorate Concentration	mg/L	1.1	1.1	0.22	5.5	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Nitrate Concentration	mg/L	15	15	15	15	5	30	15	15	15	15	15	15	15
Dissolved Oxygen Concentration	mg/L	5	5	5	5	2	8	5	5	5	5	5	5	5
Depth to Water	m bgs	3	3	3	3	3	3	3	3	30	3	3	3	3
	ft bgs	10	10	10	10	10	10	10	10	100	10	10	10	10
Vertical Saturated Thickness	m	9	9	9	9	9	9	9	9	9	3	15	9	9
	ft	30	30	30	30	30	30	30	30	30	10	50	30	30
Cross Sectional Area of Plume	m^2	1,080	1,080	1,080	1,080	1,080	1,080	1,080	1,080	1,080	360	1,800	270	2,160
	ft^2	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	4,000	20,000	3,000	24,000
GW Seepage Velocity	m/year	10	10	10	10	10	10	1	20	10	10	10	10	10
	ft/year	33	33	33	33	33	33	3.3	66	33	33	33	33	33
Perchlorate Treatment Objective	mg/L	0.0245	0.0245	0.0245	0.0245	0.0245	0.0245	0.0245	0.0245	0.0245	0.0245	0.0245	0.0245	0.0245
Assumed Number of Pore Volumes to Flush Plume		2	2	2	2	2	2	2	2	2	2	2	2	2
Number of Barriers Perpendicular to GW Flow		1	5	1	1	1	1	1	1	1	1	1	1	1
GW Travel Time to Barrier(s)	years	24	5	24	24	24	24	240	12	24	24	24	24	24
Years to Clean Up GW	years	48	10	48	48	48	48	480	24	48	48	48	48	48

notes:

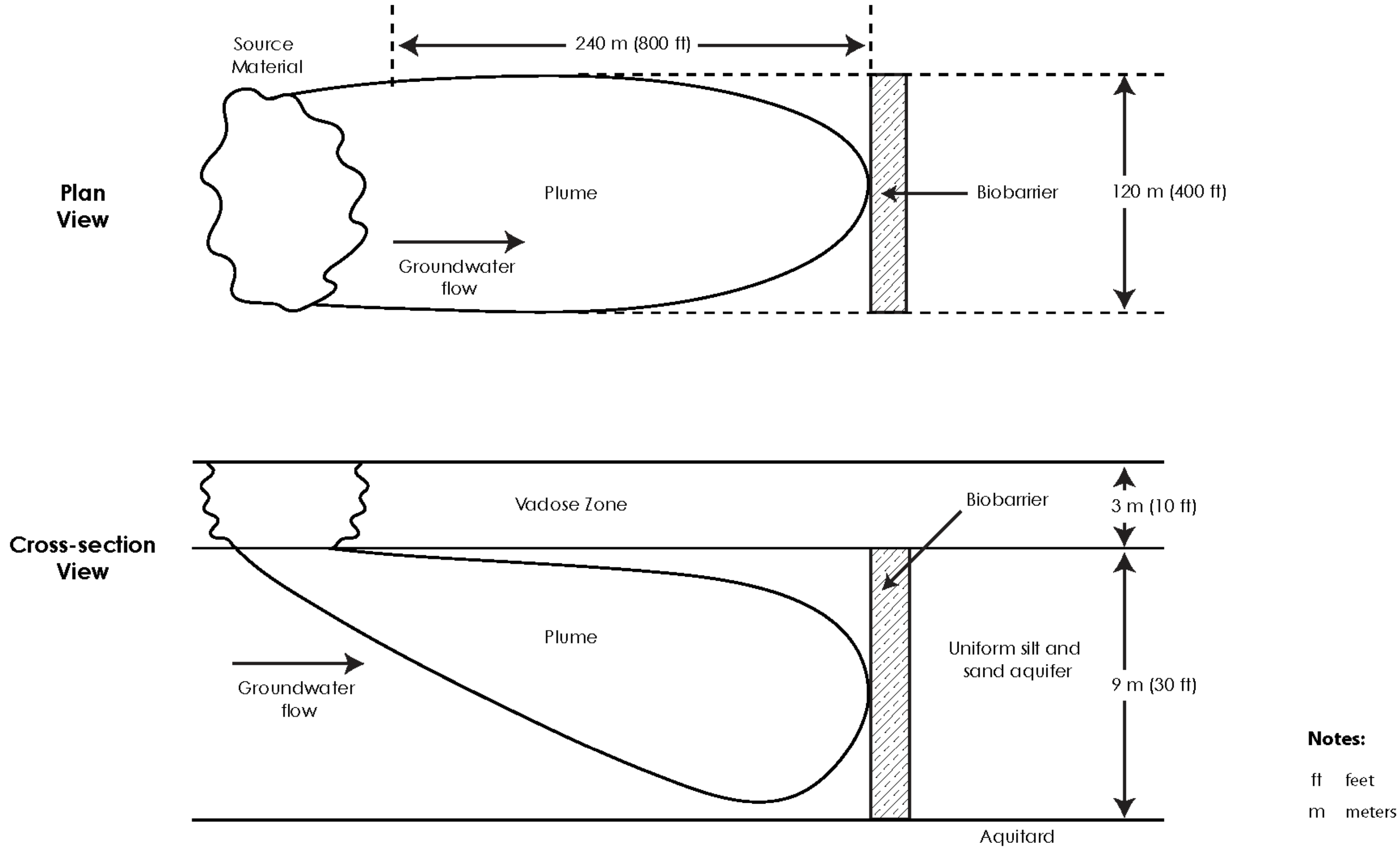
* hydraulic conductivity based on uniform silty sand aquifer

(shaded) - input parameters changed from base case

bgs - below ground surface; cm/sec - centimeters per second; ft - feet

GW - groundwater; kg - kilograms; L - liters

m - meters; mg/L - milligrams per liter; Conc. - Concentration



Notes:

ft feet

m meters

Base Case Plume and Biobarrier Configuration
Site 16 Landfill, LHAAP
Karnack, Texas

Geosyntec consultants

Guelph | December 2008

Figure **7-1**

areas which may contain a significant mass of perchlorate and contribute slowly to elevated concentrations in groundwater. A perchlorate "source" may take a variety of forms including:

1. perchlorate in the geological media above the water table (the "vadose zone") which is carried into the groundwater by water infiltrating from the surface and flushing the perchlorate into the groundwater;
2. perchlorate in the vadose zone which dissolves into the groundwater as groundwater elevations increase (possibly on an intermittent basis) and saturate the vadose zone containing the perchlorate;
3. perchlorate disposed of below the water table in a manner that allows the perchlorate to be releases into the groundwater over an extended period of time; and
4. perchlorate which was released into the groundwater at high concentrations and diffused into low hydraulic conductivity (K) units in the geological media and which continue to diffuse out of the low K units as the upgradient source of perchlorate is depleted.

If the "source" material is not treated, it may continue to feed the plume for an extended period of time and it may be necessary to treat the plume for a longer period of time until the source zone is sufficiently depleted. The semi-passive remedial approach could be used in a modified configuration to treat source areas below the water table, but estimating the costs for this application is beyond the scope of this document. Sources of perchlorate above the water table may be treated using other approaches such as enhanced flushing of the vadose zone.

To obtain a clearer picture of life-cycle costs for the semi-passive EISB and pump and treat systems, estimates include the Net Present Value (NPV) of future costs. The NPV calculations provide cash flow analysis for 30 years, showing the costs by category for each year. The future costs are only carried forward for 30 years on the basis that the NPV of future costs beyond the 30 year time frame are small and the future costs beyond the 30 year period of time are difficult to predict. o&m and long term monitoring costs are discounted at a rate of 3%, to develop the NPV estimates of future costs (DoD, 1995). The rate of 3% is based on the U.S. Federal Government Office of Management and Budget "Real Interest Rates on Treasury Notes and Bonds" for 20-year and 30-year notes and bonds of 2.8% (Office of Management and Budget, 2008).

The cost model also estimates the impact of changes in site characteristics and design parameters. Using the template site as a baseline condition, site characteristics and design parameters (e.g., depth to groundwater, contaminant plume width, and groundwater velocity) were varied individually and the twelve iterations are shown in Table 7-1. This specific analysis provides some insight into how capital, o&m, and long-term monitoring costs are affected by changing specific variables.

The costing for the template site and other cases considered assumes that source zone treatment is complete or at least that there is no continuing source of groundwater contamination. If the source is not treated, operation of the biobarrier beyond the anticipated time period required to achieve clean up objectives would likely be required.

The base case assumes a homogenous silty sand aquifer from a depth of 3 meters (m) (approximately 10 feet [ft]) below ground surface to 12 m (40 ft) below ground surface with a hydraulic conductivity of 0.001 cm/sec, a horizontal gradient of 0.008 m/m and a porosity of 0.25. These aquifer characteristics result in a groundwater seepage velocity of approximately 10 m/year (yr) (33 ft/yr). The plume of perchlorate impacted groundwater extends along the direction of groundwater flow for 240 m (800 ft) and is 120 m (400 ft) in width. The concentration of perchlorate at the upgradient side of the plume is 2 mg/L and the concentration on the downgradient side is 1.1 mg/L. Oxygen and nitrate will contribute demand for electron donor and the assumed concentrations of dissolved oxygen and nitrate are 5 mg/L and 15 mg/L respectively.

The base case also assumes that two pore volumes of clean water will need to flush through the impacted areas to achieve the clean up objectives. In reality, the number of pore volumes of clean water required to flush through the subsurface to achieve target treatment objectives will be determined by a number of factors, such the degree of heterogeneity of the geological media. Variations in the K of the aquifer material can allow significant mass of perchlorate to diffuse into low K layers and then act as an ongoing source of perchlorate to the higher K zone as the perchlorate is flushed from the higher K zones. In most geological settings, more than two pore volumes will be required to achieve treatment objectives and longer term operation of the remedial measures will be required. The assumption that two pore volumes of flushing are required to achieve treatment objectives could only be valid for situations where there is very uniform K of the geological media and is likely an optimistic assumption for most real world situations.

The base case design incorporates one biobarrier on the downgradient edge of the plume to treat water as it flows across the line of the biobarrier. Based on the groundwater seepage velocity of 10 m/yr (33 ft/yr), a plume that extends for 240 m (800 ft) along the direction of groundwater flow and the assumed need to flush two pore volumes of clean water through the impacted aquifer to achieve clean up standards, it would be expected to take approximately 48 years for the plume to be treated in the base case. If more than two pore volumes of flushing are actually required to achieve treatment objectives, the biobarrier would need to be operated beyond the 30-year time frame considered in this costing exercise but the concentrations to be treated would likely be reduced significantly and operating requirements reduced. The costs of this potential future operation would be incurred more than 30 years into the future and the NPV of these costs would not be as significant as the costs incurred for operation in the near and medium term (i.e., less than 30 years).

The perchlorate treatment objective that was used for the template site was based on the chronic exposure reference dose (and the resulting drinking water equivalent concentration) selected by the USEPA in 2005 (http://www.epa.gov/iris/subst/1007.htm) of 24.5 μg/L (0.0245 mg/L). A lower treatment objective would increase the costs associated with the implementation of the approaches presented here.

The semi-passive bioremediation approach considered can achieve low treatment criteria (i.e., below 0.004 mg/L) but to achieve lower target treatment criteria, a higher safety factor will be required in the design and operation of each of the remedies such that pockets or layers of low K geological material containing untreated groundwater with some perchlorate do not remain or transmit perchlorate in groundwater following treatment and the system may need to be operated for a longer period of time. If a very low target treatment objective is required, even small pockets or layers of untreated groundwater could result in groundwater samples exceeding the target criteria. Layers of low K geological material exist at many sites where inter-bedded clay, silts, and sands are present and can serve as longer term repositories for perchlorate from which diffusion is the dominant transport mechanism. These pockets or layers may release perchlorate to flowing groundwater after treatment of perchlorate in the higher K units has been completed.

As discussed above, the presence of significant low K repositories of perchlorate and low target treatment concentrations would affect the assumption used in the base case that two pore volumes of groundwater need to be flushed through the plume to achieve the target treatment objectives. If additional clean groundwater needs to be flushed through the plume area to achieve remedial action objectives then the treatment system will need to be operated for a longer period of time and incur additional long-term o&m and monitoring costs. The additional safety factor in design and possibly longer term operation will increase costs to achieve lower target treatment objectives but the impact of a specific change in the target treatment concentration is difficult to predict without extensive and very detailed site characterization and contaminant transport modeling.

The semi-passive biobarrier alternative assumes that a series of injection and extraction wells will be installed along the alignment of the biobarrier and a groundwater recirculation system will be constructed to recirculate groundwater and distribute electron donor across the biobarrier. Groundwater will be recirculated between injection and extraction wells and a soluble electron donor will be added to the water being recirculated to distribute the electron donor across the plume of perchlorate impacted groundwater. For the purpose of this cost model it is assumed that this initial system installation is the same as would be used for an active approach to the addition of electron donor. The costing has been developed based on circulating groundwater and adding electron over a period of 3 weeks, after which the recirculation system will be shut down for a period of 9 months. Operation will continue on a cycle of 3 weeks of groundwater recirculation and addition of electron donor every 9 months. The capitals costs for the installation would be similar to that of an active system but the operating costs would be reduced as a result of the reduced operating requirements and reduced potential for biofouling of injection wells. In some situations it may be possible to reduce the capital expenditure for the semi-passive systems by using simple controls and more manual operations than would be possible with active recirculation systems. In some situations, the capital costs can be further reduced by constructing small mobile units that can be used to recirculate groundwater and add electron donor at one set of wells and then moved to wells at another location to recirculate groundwater and add electron donor.

The groundwater extraction and treatment or pump and treat system included for comparison would be similar to the biobarrier system in that a row of extraction and injection wells would be used to bring groundwater to the surface and to re-inject the groundwater but rather than amending the groundwater with electron donor the groundwater would be treated to remove perchlorate prior to reinjection on a continuous basis. The groundwater treatment component of this system would be a small-scale bioreactor to degrade perchlorate.

A series of twelve variations in site conditions and/or design parameters were developed and the cost implications of these variations were estimated. The first variation of the base case, Case 2: Accelerated Clean Up Case, utilizes five biobarriers aligned perpendicular to the direction of groundwater flow distributed every 48 m (160 ft) within the 240 m (800 ft) long plume. This will provide treatment of the plume at one downgradient and four intermediate locations rather than just at the downgradient edge of the plume. Based on the seepage velocity of 10 m/yr (33 ft/yr) and the assumption that two pore volumes of clean water need to flow through the plume area to achieve clean up, this case will require approximately 10 years to treat the groundwater rather than the 48 years of the base case.

The 3rd and 4th cases incorporate reduced and elevated concentrations of perchlorate in groundwater as shown in Table 7-1. The 5th and 6th cases assume lower and higher concentrations of nitrate and dissolved oxygen which will result in a higher and lower demand for electron donor. The 7th and 8th cases incorporate lower and higher groundwater seepage velocities resulting from changes in the hydraulic gradient from the base case. The 9th case assumes that the depth to groundwater is 30 m (100 ft) rather than the 3 m (10 ft) in the base case. The 10th and 11th cases assume thin and thick vertical interval of 3 m (10 ft) and 15 m (50 ft) rather than the 9 m (30 ft) of the base case. The 12th and 13th case assume a narrow plume (30 m [100 ft] in width) and a wide plume (240 m [800 ft] in width) rather than the 120 m (400 ft) width of the base case.

The costs of the base case and the variations are discussed in Section 7.3.

7.2 COST DRIVERS

The costs to implement EISB for perchlorate impacted groundwater using the semi-passive approach for the addition of electron donor will vary significantly from site to site. The key costs drivers are listed below followed by a brief discussion of the impact on cost.

- **Width of Plume (perpendicular to the direction of groundwater flow) –** Treatment systems for wider plumes require more recirculation wells, equipment, electron donor and labor to operate. Some system costs, such as design and mobilization will be relatively insensitive to the size of a system but many costs will increase in direct proportion with an increase in the width of the area to be treated.

- **Length of Plume to be Treated –** Treatment systems may be designed to treat the entire length of a plume in a shorter time period by installing recirculation wells at many

locations along the length of the plume or they may be designed to treat a plume over a longer period of time as the groundwater flows through a few biobarriers aligned perpendicular to the direction of groundwater flow. In either case, the costs will be higher for plumes of greater length. Systems designed to treat plumes quickly will require more recirculation wells, more equipment, more electron donor and more labor to operate than systems designed to treat perchlorate over a longer period of time. Systems designed to treat plumes as they flow through a small number of biobarriers will need to operate for longer periods of time if the plume to be treated has a greater length.

- **Vertical thickness of the area of impacted groundwater –** Systems designed to treat plumes with a greater vertical thickness will be more expensive as they will require longer screen in the recirculation wells, higher capacity pumps, piping and other equipment, more electron donor and some additional labor to operate. As with the length of the plume, some system costs, such as design and mobilization costs, will be relatively insensitive to the size of a system but many costs will increase in direct proportion with an increase in the vertical thickness of the area to be treated.

- **Depth of the interval to be treated –** System designed to treat perchlorate at greater depths will be somewhat more expensive than shallow plumes as a result of the higher costs of installation recirculation wells. Most other capital and operating costs will not be impacted greatly by the need to treat deeper plumes of perchlorate impacted groundwater.

- **The area of the plume of impacted groundwater to be treated –** As discussed above, systems may be designed to treat the entire length of a plume on a short time frame by installing recirculation wells at many locations along the length of the plume or they may be designed to treat a plume over a longer period of time as the groundwater flows through a few biobarriers aligned perpendicular to the direction of groundwater flow. Treating the entire plume will increase the initial capital costs relative to treating the plume as water flows through a small number of biobarriers but the long-term costs will be less because treatment will be completed over a shorter period of time.

- **Ambient groundwater velocity –** Systems design to treat higher ambient groundwater velocities will be more expensive because: higher groundwater recirculation rates or additional recirculation wells will likely be required to distribute electron donor across the width of the plume and the higher groundwater velocities will result in greater demand for electron donor as higher quantities of perchlorate and other electron acceptors will be flowing through the target treatment zone. A higher groundwater velocity will, however, usually allow for clean up criteria to be achieved in a shorter period of time as water flows faster through the impacted geological media.

- **Hydraulic conductivity (K) of the geological media containing the impacted groundwater –** Sites with a high K will generally have high groundwater velocities and associated higher costs as discussed above. Systems at low K sites will generally be less

expensive because of the lower groundwater velocity but the amount of the costs savings may be reduced somewhat by the need for a greater number of recirculation wells which may be required to recirculate a sufficient amount of groundwater to maintain hydraulic control.

- **The variation in the hydraulic conductivity (K) of different layers in the geological media –** Sites with a high degree of variation in the K of different layers in the geological media will have increases costs as a result of the greater number of pore volumes of clean water required to flush through the subsurface to achieve target treatment objectives. Variations in the K of the aquifer material can allow significant mass of perchlorate to diffuse into low K layers and then act as an ongoing source of perchlorate to the higher K zone as the perchlorate is flushed from the higher K zones. The need for more pore volumes of water to flush the subsurface will result in the need to operate the system for a longer period of time with an associated increase in OM&M costs.

- **Concentration of perchlorate in impacted groundwater** – Higher concentrations of perchlorate may not impact the initial capital costs to a large extent but will increase OM&M costs for systems in two ways. First, higher concentrations of perchlorate will require more clean water to flush the perchlorate from the geological media and therefore a longer period of operation. Second, the higher concentrations will require more electron donor to degrade the perchlorate present, although the impact of this factor may be small at most sites where the total demand for electron donor is dominated by parameters such DO, nitrate and sulfate rather than by the perchlorate concentration.

- **Target treatment concentration –** EISB can achieve low treatment criteria (i.e., below 4 μg/L) but the lower the target treatment criteria, the higher the safety factor required in the design and operation of the system so that pockets or layers of low K geological material containing untreated groundwater with some perchlorate do not remain or transmit perchlorate in groundwater following treatment. If a very low target treatment objective is required, even small pockets or layers of untreated groundwater could result in groundwater samples exceeding the target criteria and operation of the system for a long period of time may be required. Layers of low K geological material exist at many sites where inter-bedded clay, silts, and sands are present and can serve as longer term repositories for perchlorate from which diffusion is the dominant transport mechanism. These pockets or layers may release perchlorate to flowing groundwater after substantial treatment of perchlorate in the higher K units has been completed.

- **Concentration of other electron acceptors** – High concentration of other electron acceptors such as DO, nitrate and sulfate will increase the amount of electron donor required to degrade perchlorate. The increased electron donor demand will increase the operating costs somewhat for the system.

7.3 COST ANALYSIS

The detailed breakdown of the estimated capital costs, annual o&m costs, long-term monitoring costs and the NPV of these costs for the semi-passive EISB and for the equivalent P&T system are presented in Tables 7-2 and 7-3. A summary of these costs is presented in Table 7-4.

The capital cost, including design, installation of wells, installation of the groundwater recirculation and amendment system and system start up and testing for the semi-passive EISB system is approximately $430K and the annual o&m cost is estimated to be $39K per year. The NPV of the operation and maintenance represents an additional $780K of costs over a 30-year life. The NPV of the long-term monitoring costs is estimated to be $350K to give a total current value cost for the alternative of $1,560K. The total cost of the remedy over 30 years is estimated to be $2,060K. The cross sectional area of the plume for this scenario is 1,080 square meters (m^2) or 12,000 square feet (ft^2). The unit costs for capital and annual o&m are therefore $398/$m^2$ ($36/$ft^2$) and $36/$m^2$ ($3/$ft^2$) respectively.

The capital cost for the pump and treat alternative is $490K; somewhat higher than for the semi-passive biobarriers at $430K. The o&m costs are estimated to be $74K per year versus $39K for the semi-passive biobarriers. The NPV of the o&m costs for the pump and treat approach are estimated to be $1,470K, also higher than for the EISB alternative of $780K. The NPV of the long-term monitoring costs is estimated to be same as for the EISB alternative at $350K to give a total current value cost for the alternative of $2,310K versus $1,560K for EISB. The total cost of the remedy over 30 years is estimated to be $3,160K versus $2,060K for EISB. The unit costs for capital and annual o&m for the pump and treat alternative is $453/$m^2$ ($40.83/$ft^2$) and $68.50/$m^2$ ($6.2/$ft^2$) respectively.

Figure 7-2 shows the cumulative costs by year for the EISB and pump and treat alternatives evaluated above.

Table 7-5 shows the estimates of the impact of variations in the site characteristics and design parameters on the costs for the EISB technology. Of the changes in site characteristics and design parameters considered in this evaluation, the most significant cost driver is the decision to accelerate the clean up of the entire zone of perchlorate impacted groundwater rather than treating groundwater at the downgradient limit and allowing the impacted groundwater to flow through this location over time. As a result of the size of the plume a significant number of separate biobarrier systems would be required to provide sufficient coverage of the impacted groundwater to accelerate clean up.

TABLE 7-2: COST ESTIMATE FOR EISB WITH SEMI-PASSIVE ADDITION OF ELECTRON DONOR
Site 16 Landfill, LHAAP, Karnack, Texas

		Year (n) Costs ($)							
CAPITAL COSTS	COST ($)	1	2	3	4	5	6	7 to 30	NPV*
System Design									
- Engineering/Geology	26,700	26,700	--	--	--	--	--	--	26,700
- Work Plan	15,000	15,000	--	--	--	--	--	--	15,000
- Groundwater Modeling	30,000	30,000	--	--	--	--	--	--	30,000
- Permitting	3,500	3,500	--	--	--	--	--	--	3,500
- Management Support	4,600	4,600	--	--	--	--	--	--	4,600
- Other Planning/Preparation	11,000	11,000	--	--	--	--	--	--	11,000
Well Installation (9 System Wells - 4" PVC using Air Rotary & 10 Monitoring Wells - 2" PVC using Geoprobe)									
- Mobilization	1,400	1,400	--	--	--	--	--	--	1,400
- Labor									
- Field Tech	4,950	4,950	--	--	--	--	--	--	4,950
- Geologist	8,550	8,550	--	--	--	--	--	--	8,550
- Management Support	2,000	2,000	--	--	--	--	--	--	2,000
- Clerical/Administrative Support	500	500	--	--	--	--	--	--	500
- Travel/Per Diem	2,800	2,800	--	--	--	--	--	--	2,800
- Subcontracted Driller (Air Rotary)	39,000	39,000	--	--	--	--	--	--	39,000
- Subcontracted Driller (Geoprobe)	13,000	13,000	--	--	--	--	--	--	13,000
- Subcontracted Surveyor	3,000	3,000	--	--	--	--	--	--	3,000
- Equipment	1,700	1,700	--	--	--	--	--	--	1,700
- Materials, Chemicals, and Consummables	6,000	6,000	--	--	--	--	--	--	6,000
- Soil/Sludge/Debris Excavation, Collection, Control/Disposal	3,300	3,300	--	--	--	--	--	--	3,300
System Installation									
- Mobilization	1,240	1,240	--	--	--	--	--	--	1,240
- Labor:									0
- Env. Sci II – 9 hours for 15 days @ $85/hr (supervision)	11,500	11,500	--	--	--	--	--	--	11,500
- Construction/Env. Spec. I – 9 hours,30 days,3 men	45,000	45,000	--	--	--	--	--	--	45,000
- Management Support	4,600	4,600	--	--	--	--	--	--	4,600
- Report Development	5,000	5,000	--	--	--	--	--	--	5,000
- Clerical/Administrative Support	700	700	--	--	--	--	--	--	700
- Travel/Per Diem	4,100	4,100	--	--	--	--	--	--	4,100
- Daily mileage – 25 miles/day for 105 days @ $.485/mi	1,200	1,200	--	--	--	--	--	--	1,200
- Equipment									0
- H&S; vehicle; hand tools @ $140/d for 30 days	4,200	4,200	--	--	--	--	--	--	4,200
- 10' Conex Box	4,900	4,900	--	--	--	--	--	--	4,900
- PLC and SCADA system	40,000	40,000	--	--	--	--	--	--	40,000
- Extraction Well Pumps w controllers and level sensors (5 @2,500 ea)	12,500	12,500	--	--	--	--	--	--	12,500
- Pressure transducers (injection wells only 9@1500)	13,500	13,500	--	--	--	--	--	--	13,500
- PVC piping/tubing and valves	15,000	15,000	--	--	--	--	--	--	15,000
- Biofouling control system (Bio-Cide OLAS)	3,500	3,500	--	--	--	--	--	--	3,500
- Flow meters (5 ea x 1800 - total flow only) - extraction wells	9,000	9,000	--	--	--	--	--	--	9,000
- Pitless Adaptors - All wells 9@$350 ea	3,150	3,150	--	--	--	--	--	--	3,150
- Tankage (1 x 500 gal)	1,000	1,000	--	--	--	--	--	--	1,000
- Metering pumps (1 for citric acid; 1 backup)	1,600	1,600	--	--	--	--	--	--	1,600
- Rack Assembly for piping, filters, flow meter	3,000	3,000	--	--	--	--	--	--	3,000
- Filter assembly	500	500	--	--	--	--	--	--	500
- Miscellaneous materials and supplies	10,000	10,000	--	--	--	--	--	--	10,000
- Electrical equipment	4,000	4,000	--	--	--	--	--	--	4,000
- Solenoid valves	2,000	2,000	--	--	--	--	--	--	2,000
- Subcontracts Labor:			--	--	--	--	--	--	0
- Power drop and electrical to box – 9 hr for 5 days @ $65/hr x 1 men	2,925	2,925	--	--	--	--	--	--	2,925
- Phone/DSL communication	1,000	1,000	--	--	--	--	--	--	1,000
- Control panel, electrical, and SCADA installation and testing; 9 hr for 10 days @ $85/hr x 2 men	15,300	15,300	--	--	--	--	--	--	15,300
- Per Diem & Lodging: 30 days total @ $130/man/day (est.)	3,900	3,900	--	--	--	--	--	--	3,900
- Shipping of Conex Box to Site	4,000	4,000	--	--	--	--	--	--	4,000
- Rental backhoe w operator - $2000/wk x 1 week to bury pipe	2,000	2,000	--	--	--	--	--	--	2,000
- Materials, Chemicals, Substrates and Consummables	2,250	2,250	--	--	--	--	--	--	2,250
- Utilities/Fuel	1,000	1,000	--	--	--	--	--	--	1,000
- Soil/Sludge/Debris Excavation, Collection, Control/Disposal	300	300	--	--	--	--	--	--	300
Start-up and Testing	18,000	18,000	--	--	--	--	--	--	18,000
TOTAL CAPITAL COSTS	**428,865**	428,865	--	--	--	--	--	--	**428,865**
OPERATION & MAINTENANCE COSTS	**COST ($)**								
Mobilization	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	60,565
Labor		-	-	-	-	-	-	-	0
- Field Tech (O&M)	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	70,660
- Field Tech (Well Redevelopment)	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	30,283
- Management Support	4,600	4,600	4,600	4,600	4,600	4,600	4,600	4,600	92,867
- Report Development	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	60,565
- Clerical/Administrative Support	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	20,188
- Travel/Per Diem	1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,400	28,264
- Equipment & Replacement Parts	15,000	-	15,000	15,000	15,000	15,000	15,000	15,000	287,827
- Materials, Chemicals, Substrates and Consummables	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	100,942
- Utilities/Fuel	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	20,188
- Soil/Sludge/Debris Excavation, Collection, Control/Disposal	300	300	300	300	300	300	300	300	6,057
TOTAL OPERATION & MAINTENANCE COSTS	**39,300**	24,300	39,300	39,300	39,300	39,300	39,300	39,300	**778,406**
LONG-TERM MONITORING COSTS	**COST ($)**								
Field Sampling	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	70,660
Analytical Costs	3,320	3,320	3,320	3,320	3,320	3,320	3,320	3,320	67,026
Regulatory/institutional Reporting	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	20,188
Management Support	2,760	2,760	2,760	2,760	2,760	2,760	2,760	2,760	55,720
Clerical/Administrative Support	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	24,226
Additional Field Sampling Costs for Quarterly Sampling	10,500	10,500	10,500	10,500	10,500	10,500	--	--	49,530
Additional Analytical Costs for Quarterly Sampling	10,000	10,000	10,000	10,000	10,000	10,000	--	--	47,171
Additional Regulatory/institutional Reporting Costs for Quarterly Sampling	3,000	3,000	3,000	3,000	3,000	3,000	--	--	14,151
TOTAL LONG-TERM MONITORING COSTS		**35,280**	**35,280**	**35,280**	**35,280**	**35,280**	**11,780**	**11,780**	**348,672**
TOTAL CAPTIAL AND OM&M COSTS BY YEAR ($)		**488,445**	**74,580**	**74,580**	**74,580**	**74,580**	**51,080**	**51,080**	**1,555,943**

notes:

NPV - Net Present Value   * - NPV calculated based on a 3% discount rate   OM&M - Operation, Maintenance and Monitoring

TABLE 7-3: COST ESTIMATE FOR PUMP AND TREAT
Site 16 Landfill, LHAAP, Karnack, Texas

		Beginning of Year (n) Costs ($)							
CAPITAL COSTS	**COST ($)**	**1**	**2**	**3**	**4**	**5**	**6**	**7 to 30**	**NPV***
System Design									
- Engineering/Geolog	26,700	26,700	--	--	--	--	--	--	26,700
- Work Plan	15,000	15,000	--	--	--	--	--	--	15,000
- Groundwater Modeling	30,000	30,000	--	--	--	--	--	--	30,000
- Permitting	3,500	3,500	--	--	--	--	--	--	3,500
- Management Support	4,600	4,600	--	--	--	--	--	--	4,600
- Other Planning/Preparation	11,000	11,000	--	--	--	--	--	--	11,000
Well Installation (9 System Wells - 4" PVC using Air Rotary & 10 Monitoring Wells - 2" PVC using Geoprobe)									
- Mobilization	1,400	1,400	--	--	--	--	--	--	1,400
- Labor									
- Field Tech	4,950	4,950	--	--	--	--	--	--	4,950
- Geologist	8,550	8,550	--	--	--	--	--	--	8,550
- Management Support	2,000	2,000	--	--	--	--	--	--	2,000
- Clerical/Administrative Support	500	500	--	--	--	--	--	--	500
- Travel/Per Diem	2,800	2,800	--	--	--	--	--	--	2,800
- Subcontracted Driller (Air Rotary)	39,000	39,000	--	--	--	--	--	--	39,000
- Subcontracted Driller (Geoprobe)	13,000	13,000	--	--	--	--	--	--	13,000
- Subcontracted Surveyor	3,000	3,000	--	--	--	--	--	--	3,000
- Equipment	1,700	1,700	--	--	--	--	--	--	1,700
- Materials, Chemicals, and Consummables	6,000	6,000	--	--	--	--	--	--	6,000
- Soil/Sludge/Debris Excavation, Collection, Control/Disposa	3,300	3,300	--	--	--	--	--	--	3,300
System Installation									
- Mobilization	1,240	1,240	--	--	--	--	--	--	1,240
- Labor:									0
- Env. Sci II – 9 hours for 15 days @ $85/hr (supervision)	11,500	11,500	--	--	--	--	--	--	11,500
- Construction/Env. Spec. I – 9 hours,30 days,3 men	45,000	45,000	--	--	--	--	--	--	45,000
- Management Support	4,600	4,600	--	--	--	--	--	--	4,600
- Report Development	5,000	5,000	--	--	--	--	--	--	5,000
- Clerical/Administrative Support	700	700	--	--	--	--	--	--	700
- Travel/Per Diem	4,100	4,100	--	--	--	--	--	--	4,100
- Daily mileage – 25 miles/day for 105 days @ $.485/mi	1,200	1,200	--	--	--	--	--	--	1,200
- Equipment									0
- H&S; vehicle; hand tools @ $140/d for 30 days	4,200	4,200	--	--	--	--	--	--	4,200
- 10' Conex Box	4,900	4,900	--	--	--	--	--	--	4,900
- PLC and SCADA system	40,000	40,000	--	--	--	--	--	--	40,000
- Extraction Well Pumps w controllers and level sensors (5 @2,500 ea	12,500	12,500	--	--	--	--	--	--	12,500
- Pressure transducers (injection wells only 9@1500)	13,500	13,500	--	--	--	--	--	--	13,500
- PVC piping/tubing and valves	15,000	15,000	--	--	--	--	--	--	15,000
- Biofouling control system (Bio-Cide OLAS)	0	-	--	--	--	--	--	--	0
- Flow meters (5 ea x 1800 - total flow only) - extraction well	9,000	9,000	--	--	--	--	--	--	9,000
- Pitless Adaptors - All wells 9@$350 ea	3,150	3,150	--	--	--	--	--	--	3,150
- Tankage (1 x 500 gal)	1,000	1,000	--	--	--	--	--	--	1,000
- Metering pumps (1 for citric acid; 1 backup)	0	-	--	--	--	--	--	--	0
- Rack Assembly for piping, filters, flow mete	3,000	3,000	--	--	--	--	--	--	3,000
- Filter assembly	500	500	--	--	--	--	--	--	500
- Miscellaneous materials and supplies	10,000	10,000	--	--	--	--	--	--	10,000
- Electrical equipment	4,000	4,000	--	--	--	--	--	--	4,000
- Solenoid valves	2,000	2,000	--	--	--	--	--	--	2,000
- Water Treatment System	60,000	60,000							60,000
- Subcontracts Labor:			--	--	--	--	--	--	0
- Power drop and electrical to box – 9 hr for 5 days @ $65/hr x 1 men	2,925	2,925	--	--	--	--	--	--	2,925
- Phone/DSL communication	1,000	1,000	--	--	--	--	--	--	1,000
- Control panel, electrical, and SCADA installation and testing 9 hr for 10 days @ $85/hr x 2 men	15,300	15,300	--	--	--	--	--	--	15,300
- Per Diem & Lodging: 30 days total @ $130/man/day (est.)	3,900	3,900	--	--	--	--	--	--	3,900
- Shipping of Conex Box to Site	4,000	4,000	--	--	--	--	--	--	4,000
- Rental backhoe w operator - $2000/wk x 1 week to bury pipe	2,000	2,000	--	--	--	--	--	--	2,000
- Materials, Chemicals, Substrates and Consummables	2,250	2,250	--	--	--	--	--	--	2,250
- Utilities/Fuel	1,000	1,000	--	--	--	--	--	--	1,000
- Soil/Sludge/Debris Excavation, Collection, Control/Disposa	300	300	--	--	--	--	--	--	300
Start-up and Testing	25,000	25,000	--	--	--	--	--	--	25,000
TOTAL CAPITAL COSTS	**490,765**	490,765	--	--	--	--	--	--	**490,765**
OPERATION & MAINTENANCE COSTS	**COST ($)**								
Mobilization	6,300	6,300	6,300	6,300	6,300	6,300	6,300	6,300	127,187
Labor		-	-	-	-	-	-	-	0
- Field Tech (O&M)	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	504,711
- Field Tech (Well Redevelopment	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	40,377
- Management Support	4,600	4,600	4,600	4,600	4,600	4,600	4,600	4,600	92,867
- Report Development	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	60,565
- Clerical/Administrative Support	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	20,188
- Travel/Per Diem	1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,400	28,264
- Equipment & Replacement Parts	25,000	-	25,000	25,000	25,000	25,000	25,000	25,000	479,711
- Materials, Chemicals, Substrates and Consummables	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	60,565
- Utilities/Fuel	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	48,452
- Soil/Sludge/Debris Excavation, Collection, Control/Disposa	300	300	300	300	300	300	300	300	6,057
TOTAL OPERATION & MAINTENANCE COSTS	**74,000**	49,000	74,000	74,000	74,000	74,000	74,000	74,000	**1,468,946**
LONG-TERM MONITORING COSTS	**COST ($)**								
Field Sampling	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	70,660
Analytical Costs	3,320	3,320	3,320	3,320	3,320	3,320	3,320	3,320	67,026
Regulatory/institutional Reporting	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	20,188
Management Support	2,760	2,760	2,760	2,760	2,760	2,760	2,760	2,760	55,720
Clerical/Administrative Support	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	24,226
Additional Field Sampling Costs for Quarterly Sampling	10,500	10,500	10,500	10,500	10,500	10,500	--	--	49,530
Additional Analytical Costs for Quarterly Sampling	10,000	10,000	10,000	10,000	10,000	10,000	--	--	47,171
Additional Regulatory/institutional Reporting Costs for Quarterly Sampling	3,000	3,000	3,000	3,000	3,000	3,000	--	--	14,151
TOTAL LONG-TERM MONITORING COSTS		**35,280**	**35,280**	**35,280**	**35,280**	**35,280**	**11,780**	**11,780**	**348,672**
TOTAL CAPTIAL AND OM&M COSTS BY YEAR ($)		**575,045**	**109,280**	**109,280**	**109,280**	**109,280**	**85,780**	**85,780**	**2,308,382**

notes:

NPV - Net Present Value * - NPV calculated based on a 3% discount rate OM&M - Operation, Maintenance and Monitoring

TABLE 7-4: SUMMARY OF COSTS FOR EISB OF PERCHLORATE IMPACTED GROUNDWATER
Site 16 Landfill, LHAAP, Karnack, Texas

Alternative	Capital Costs	Annual O&M Costs (year 2 to 30)	NPV of 30 Years of O&M Costs	NPV of 30 Years of Monitoring Costs	NPV of 30 Years of Total Remedy Costs	Total 30-Year Remedy Costs
Semi-Passive Biobarrier	$430,000	$39,000	$780,000	$350,000	$1,560,000	$2,060,000
Pump and Treat	$490,000	$74,000	$1,470,000	$350,000	$2,310,000	$3,160,000

Cross Sectional Area of Biobarrier (m^2)	1,080	1,080	1,080	1,080	1,080	1,080
Cross Sectional Area of Biobarrier (ft^2)	12,000	12,000	12,000	12,000	12,000	12,000

Unit Cost Basis ($ per m^2 of biobarrier)

Alternative	Capital Costs	Annual O&M Costs (year 2 to 30)	NPV of 30 Years of O&M Costs	NPV of 30 Years of Monitoring Costs	NPV of 30 Years of Total Remedy Costs	Total 30-Year Remedy Costs
Semi-Passive Biobarrier	$398	$36	$722	$324	$1,444	$1,907

Unit Cost Basis ($ per ft^2 of biobarrier)

Alternative	Capital Costs	Annual O&M Costs (year 2 to 30)	NPV of 30 Years of O&M Costs	NPV of 30 Years of Monitoring Costs	NPV of 30 Years of Total Remedy Costs	Total 30-Year Remedy Costs
Semi-Passive Biobarrier	$36	$3	$65	$29	$130	$172

notes: NPV - Net Present Value; current value of future costs based on a 3% annual discount rate
O&M - Operation and Maintenance

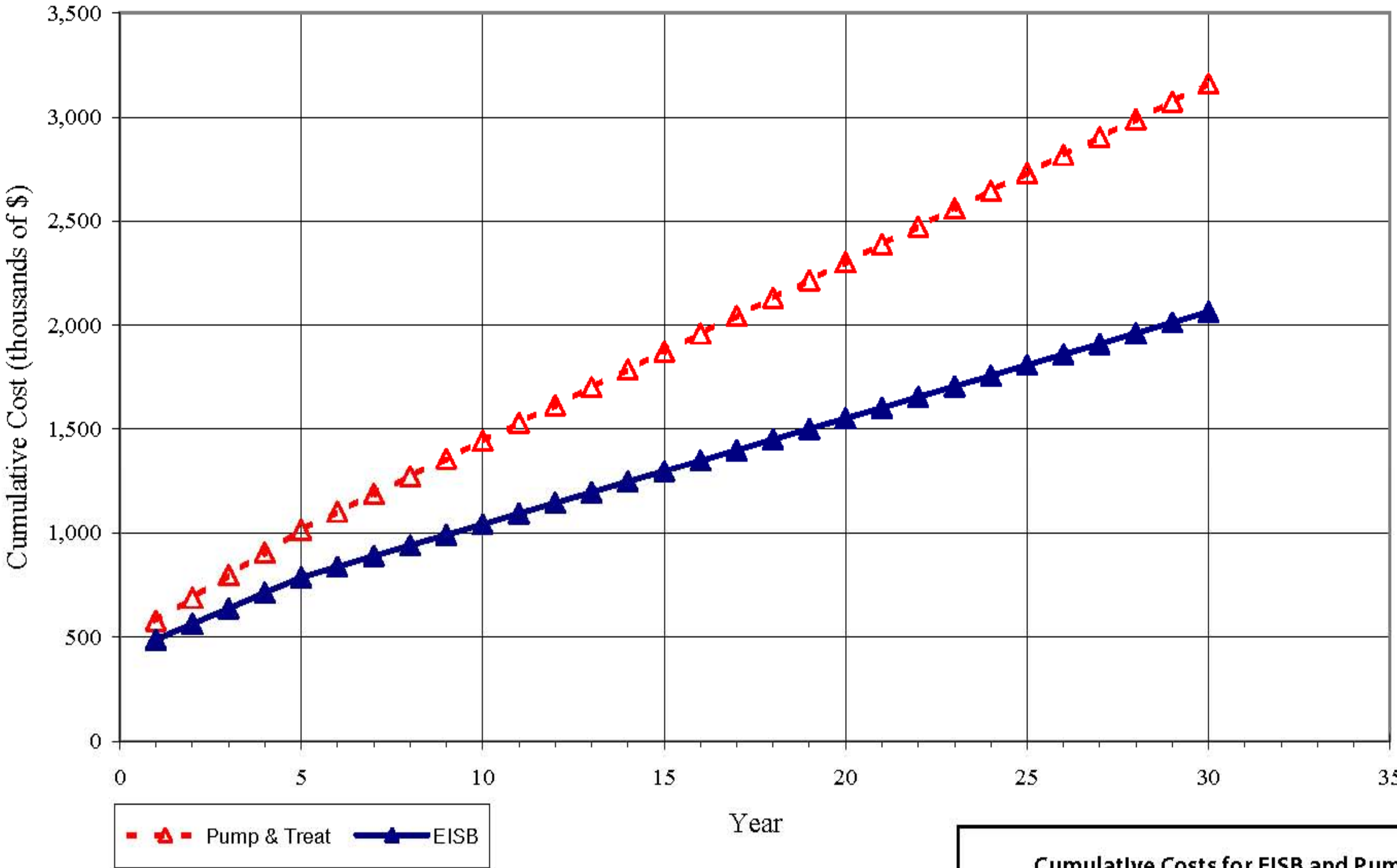
TABLE 7-5: IMPACT OF SITE CHARACTERISTICS AND DESIGN PARAMETERS ON COSTS FOR EISB
Site 16 Landfill, LHAAP, Karnack, Texas

Cost Component	Base Case	Accelerated Clean Up Case		Low Perchlorate Concentration Case		High Perchlorate Concentration Case		Low Donor Demand Case		High Donor Demand Case		Low GW Velocity Case	
	Case 1	Case 2		Case 3		Case 4		Case 5		Case 6		Case 7	
	Cost	Factor	Cost	Factor	Cost	Factor	Cost	Factor	Cost	Factor	Cost	Factor	Cost
Capital Cost	$430,000	4.50	$1,935,000	0.98	$421,400	1.05	$451,500	0.95	$408,500	1.15	$494,500	0.90	$387,000
NPV of O&M Costs	$780,000	1.75	$1,365,000	0.95	$741,000	1.05	$819,000	0.90	$702,000	1.20	$936,000	0.90	$702,000
NPV of Monitoring Costs	$350,000	1.25	$437,500	1.00	$350,000	1.00	$350,000	1.00	$350,000	1.00	$350,000	1.00	$350,000
NPV of Total Costs	$1,560,000	2.40	$3,737,500	0.97	$1,512,400	1.04	$1,620,500	0.94	$1,460,500	1.14	$1,780,500	0.92	$1,439,000

Cost Component	High GW Velocity Case		Deep GW Case		Thin Interval Case		Thick Interval Case		Narrow Plume Case		Wide Plume Case	
	Case 8		Case 9		Case 10		Case 11		Case 12		Case 13	
	Factor	Cost	Factor	Cost	Factor	Cost	Factor	Cost	Factor	Cost	Factor	Cost
Capital Cost	1.15	$494,500	1.25	$537,500	0.90	$387,000	1.15	$494,500	0.35	$150,500	1.85	$795,500
NPV of O&M Costs	1.10	$858,000	1.00	$780,000	0.90	$702,000	1.15	$897,000	0.45	$351,000	1.75	$1,365,000
NPV of Monitoring Costs	0.90	$315,000	1.00	$350,000	1.00	$350,000	1.00	$350,000	0.50	$175,000	1.50	$525,000
NPV of Total Costs	1.07	$1,667,500	1.07	$1,667,500	0.92	$1,439,000	1.12	$1,741,500	0.43	$676,500	1.72	$2,685,500

notes: All costs are in thousands of dollars
Factor - factor increase or decrease in costs relative to the Base Case
NF - not feasible, costs not estimated

NPV - Net Present Value
O&M - Operation and Maintenance



Notes: EISB - Enhanced *In Situ* Bioremediation

Cumulative Costs for EISB and Pump and Treat
Site 16 Landfill, LHAAP, Karnack, Texas

Geosyntec consultants

Figure **7-2**

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8. IMPLEMENTATION ISSUES

This section describes implementation issues with EISB using semi-passive addition of electron donor to treat perchlorate impacted groundwater.

8.1 ADDITIONAL SOURCES OF INFORMATION

Many guidance documents are available from organizations such as USEPA, Interstate Technology & Regulatory Council (ITRC), and Air Force Centre for Engineering and the Environment (AFCEE) dealing with EISB for perchlorate and chlorinated solvents. Many design issues with EISB for chlorinated solvents are also common to perchlorate. SERDP/ESTCP is also expected to publish a document in the fall of 2008 dealing with EISB for perchlorate. A list of recent relevant guidance documents is presented below:

- Interstate Technology & Regulatory Council Perchlorate Team. 2005. Perchlorate: Overview of Issues, Status, and Remedial Options. September 2005. http://www.itrcweb.org/Documents/PERC-1.pdf

- Interstate Technology & Regulatory Council Perchlorate Team. 2008. Remediation Technologies for Perchlorate Contamination in Water and Soil. March 2008. http://www.itrcweb.org/Documents/PERC-2.pdf

- Interstate Technology & Regulatory Council Bioremediation of DNAPL Team. 2008. In Situ Bioremediation and Chlorinated Ethene: DNAPL Source Zones. June 2008. http://www.itrcweb.org/Documents/bioDNPL_Docs/BioDNAPL3.pdf

- Interstate Technology & Regulatory Council Enhanced Attenuation: Chlorinated Organics Team. 2008. Enhanced Attenuation: Chlorinated Organics. April 2008 http://www.itrcweb.org/Documents/EACO-1.pdf

- Interstate Technology & Regulatory Council In Situ Bioremediation Team. 2002. A Systematic Approach to In Situ Bioremediation in Groundwater. April 2002 http://www.itrcweb.org/Documents/ISB-8.pdf

- Permeable Reactive Barriers: Lessons Learned/New Directions. 2005. Interstate Technology & Regulatory Council Permeable Reactive Barrier Team. February 2005 http://www.itrcweb.org/Documents/PRB-4.pdf

- Solutions EIS. 2006. Protocol for Enhanced In Situ Bioremediation Using Emulsified Vegetable Oil. Prepared for ESTCP. May 2006. http://www.estcp.org/viewfile.cfm?Doc=ER%2D0221%20Final%20Protocol%20V2%2Epdf

- USEPA. 2005. Perchlorate Treatment Technology Update – USEPA Federal Facilities Forum Issue Paper. USEPA – Solid Waste and Emergence Response. May 2005. http://www.clu-in.org/download/remed/542-r-05-015.pdf

- US Air Force. 2007. Protocol for In Situ Bioremediation of Chlorinated Solvents Using Edible Oil. Prepared for Air Force Center for Engineering and the Environment (AFCEE) - Environmental Science Division – Technology Transfer Outreach Office. October 2007. http://www.clu-in.org/download/remed/Final-Edible-Oil-Protocol-October-2007.pdf

- Hoponick, J. R. 2006. Status Report on Innovative In Situ Remediation Technologies Available to Treat Perchlorate-Contaminated Groundwater. Prepared for USEPA – Office of Superfund Remediation & Technology Innovation – Technology Innovation & Field Services Division. August 2006. http://www.clu-in.org/download/studentpapers/J_Hoponick_Final.pdf

8.2 POTENTIAL ENVIRONMENTAL ISSUES

8.2.1 Regulatory Issues

The implementation of EISB in most jurisdictions requires a groundwater reinjection permit. This permit must allow for extraction of groundwater, amendment with electron donor, and reinjection of the mixture. It is not normally difficult to obtain permits to implement such a program because: 1) the groundwater that will be extracted will be reinjected close to where it was extracted; 2) electron donors normally consist of innocuous organic compounds; and 3) bioaugmentation (addition of a microbiological culture) is seldom required for EISB for treatment of perchlorate.

8.2.2 Air Discharge

The EISB process described will not normally result in discharge of chemicals to the atmosphere.

8.2.3 Wastewater Discharge

The EISB process described will not normally result in the generation of wastewater streams. Extracted groundwater is normally re-injected into the injection wells. Some small quantities of wastewater may be generated during well installation and groundwater sampling events and must be managed as they would be for other investigation derived waste.

8.2.4 Waste Storage, Treatment, and Disposal

The EISB process described will not normally result in the generation of significant waste streams. Some waste may be generated during well installation and must be managed as they would be for other investigation derived waste.

8.3 END-USER ISSUES

Potential end-users of this technology include responsible parties for contaminated sites where perchlorate is present in groundwater. End-users will have an interest in the technology because it can potentially treat groundwater *In Situ* at an overall cost much less than for conventional pump and treat remediation approaches. End-users and other stakeholders may have concerns regarding: 1) the effectiveness of the technology in reducing concentrations of target compounds below appropriate criteria; 2) potential negative impacts of excess electron donor on water quality downgradient of the treatment zone; and 3) potential negative impacts of the electron donor addition on secondary water characteristics.

8.4 PROCUREMENT ISSUES

There are no specialized equipment components required to implement EISB using the semi-passive approach and no specialized services required. There are no significant procurement issues with the application of this technology.

8.5 DESIGN ISSUES

Based on the results of the demonstration conducted at the LHAAP Site and a review of other applications of the technology potential design issue to be considered in the development of the design of semi-passive EISB systems were identified. These design issues are discussed below.

- **Sites with a low hydraulic conductivity –** It can be difficult to obtain high groundwater recirculation rates at sites where the hydraulic conductivity is low and therefore longer periods of time are required to distribute electron donor between injection and extraction wells. Sites with a low hydraulic conductivity also normally have a low groundwater velocity and therefore it will take a significant period of before electron donor or the impacts of electron donor move downgradient from the biobarrier.

- **Sites with significant variations in hydraulic conductivity –** It can be difficult or impossible to obtain a uniform distribution of electron donor at sites where there are significant variations in the hydraulic conductivity (i.e., significant interbedding of low K units). Electron donor will migrate much faster and further in higher K zones than in low K zones making it difficult to obtain uniform distribution of electron donor, however, because the flux of groundwater and of perchlorate in the higher K zones is higher than in low K zones, these higher K zones require more electron donor to degrade the perchlorate.

- **Sites with high concentrations of competing electron acceptors –** The requirements for electron donor will be high at sites with high concentrations of competing electron acceptors such as nitrate and sulfate in the groundwater. Costs for electron donor will be higher at these sites that at sites with low concentrations of competing electron acceptors.

- **Sites with high concentrations of naturally occurring metals in the soil –** Groundwater monitoring should be conducted following addition of electron donor at sites with high concentrations of naturally occurring metals in the soil to make sure that the addition of electron donor does not result in the mobilization of significant concentrations of metals to areas downgradient of where the electron donor is injected. Modest amounts of electron donor should be added initially to evaluate the potential to mobilize metals. The addition of small amounts of electron donor on a more frequent basis may be required to limit the potential to mobilize naturally occurring metals downgradient of the biobarrier.

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APPENDIX A

POINTS OF CONTACTS

TABLE A-1: List of Contacts
Site 16 Landfill, LHAAP, Karnack, Texas

Point of Contact	Organization	Phone/Fax/E-mail	Role in Project
Andy Obrochta	U.S. Army Corps of Engineers	918-669-7155; Andy.Obrochta@usace.army.mil	USACE Project Manager
Cliff Murray	U.S. Army Corps of Engineers	918-669-7573; Cliff.Murray@usace.army.mil	USACE Technical Advisor
Rose Zeiler	U. S. Army	479-484-2516, zeilerr@sill.army.mil	LHAAP Representative
Evan Cox	GeoSyntec Consultants	(519) 822-2230 Ext. 237 Fax (519) 822-3151 ecox@geosyntec.com	Project Director/Principal
Tom Krug	GeoSyntec Consultants	(519) 822-2230 Ext. 242 tkrug@geosyntec.com	Senior Project Manager
David Bertrand	GeoSyntec Consultants	(519) 822-2230 Ext. 245 dbertrand@geosyntec.com	Field Study Leader
Bill Corrigan	CES Environmental	918-669-7573; CES@Shreve.net	Site Contractor

APPENDIX B

LABORATORY MICROCOSM STUDY REORT

Prepared for:

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DRAFT

LABORATORY BIOTREATBILITY STUDY TO EVALUATE THE BIODEGRADATION OF PERCHLORATE & CHLORINATED SOLVENTS IN GROUNDWATER

Longhorn Army Ammunition Plant
Karnack, Texas

Prepared by:

SiREM
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SiREM Ref: TR0136.03
16 September 2003

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LIST OF ABBREVIATIONS

°C	degrees Celsius
°C/min	degrees Celsius per minute
cis-DCE	cis-1,2-dichloroethene
gal	US gallons
GeoSyntec	GeoSyntec Consultants, Inc.
g/L	grams per liter
kg	kilograms
L	liters
MEAL	methanol, ethanol, acetate, lactate
MeOH	methanol
MDL	method detection limit
µMOL	micromoles
min	minutes
mg/L	milligrams per liter
mL	milliliters
mL/min	milliliters per minute
PQL	practical quantitation limit
SiREM	SiREM Laboratories
TCE	trichloroethene
µL	microlitres
VC	vinyl chloride
VOCs	volatile organic compounds

1. BACKGROUND

GeoSyntec Consultants, Inc., (GeoSyntec) retained SiREM Laboratories (SiREM) to perform a biotreatability study to evaluate the potential for in situ bioremediation of perchlorate and chlorinated volatile organic compounds (VOCs), namely trichloroethylene (TCE) and its breakdown products in groundwater at the Site 16 Landfill, Longhorn Army Ammunition Plant in Karnack, Texas (the Site).

The specific objectives of the study were to:

1) Evaluate the nature, rate and extent of intrinsic anaerobic biodegradation of perchlorate and VOCs that may be occurring in the Site groundwater;

2) Evaluate the ability to improve the rate and extent of perchlorate and VOC dechlorination to environmentally acceptable end products through the addition of electron donors; and

3) Evaluate whether bioaugmentation of the Site soil and groundwater using a stable dehalorespiring microbial consortium referred to as KB-1™ improves the rate and extent of biodegradation of the chlorinated VOCs relative to electron donor addition alone.

The remainder of this report is divided into four sections. Section 2 presents the experimental approach and methods. Section 3 presents and discusses the results of the microcosm study. Section 4 presents conclusions drawn from the microcosm study.

2. APPROACH AND METHODS

The following sections summarize the approach and methods for soil and groundwater sample collection and handling (Section 2.1); microcosm construction and incubation (Section 2.2); and microcosm sampling and analysis (Section 2.3).

2.1 Sample Collection and Handling

Aquifer material and groundwater samples were express shipped under chain of custody to the SiREM laboratory.

Groundwater and aquifer material samples were received from the Site on 27 February 2003 and 27 March 2003, respectively and stored at 4 degrees celsius (°C). Two soil cores and one 4 Liter (L) jug of groundwater were received. Soil core sections were collected from a depth interval of 18 to 23 feet below ground surface. The first soil core (1 of 4) was reddish in color, dry and clay like. The second soil core (3 of 4) was medium brown, wet and sandy.

2.2 Microcosm Construction and Incubation

A total of twelve microcosms were constructed on 2 April 2003. Site groundwater and aquifer material were placed within a disposable anaerobic glove bag with the materials required to construct the various treatment and control microcosms. The glove bag was purged with a carbon dioxide/nitrogen (20:80) gas mixture to create an anaerobic environment. The aquifer material was combined and homogenized to improve reproducibility between replicates and to ensure that control and treatment microcosms contained similar starting aquifer materials. Microcosms were constructed by filling sterile 250 milliliter (mL) (nominal volume) glass bottles with 30 mL of homogenized aquifer

material and 150 mL of groundwater from site well 16WW16. The bottles were capped with a Mininert™ closure to allow repetitive sampling of the bottle with minimal losses of VOCs and to allow nutrient amendment as needed, throughout the incubation period. All controls and treatments were constructed in triplicate.

Sterile control microcosms were constructed to quantify potential abiotic and experimental losses of VOCs from the microcosms. The sterile controls were constructed by autoclaving the Site soils at 121 °C and 15 pounds per square inch pressure for 60 minutes. After autoclaving, the control microcosms were returned to the disposable glove bag, where they were filled with Site groundwater and amended with 1.5 mL of 5% mercuric chloride (equal to a final liquid concentration of 0.05%) and 0.5 mL of 5% sodium azide (equal to a final liquid concentration of 0.017%) to inhibit microbial activity. The first replicate of the sterile controls was amended with acetate and lactate.

Intrinsic control microcosms were constructed to evaluate the ability of indigenous bacteria in the Site soil and groundwater to intrinsically degrade the perchlorate and target VOCs. No electron donor or KB-1™ was added to the intrinsic controls. Treatment microcosms were amended with soluble electron donors such as methanol, ethanol, acetate and lactate (MEAL).

Microcosms were amended with electron donor on 3 April 2003 (Day 0). The MEAL microcosms were amended with 20 microliters (µL) of neat methanol, 20 µL of neat ethanol and 280 µL of a sodium acetate stock solution (75 grams per Liter [g/L]) and 250 µL of a sodium lactate stock solution (75 g/L) corresponding to a target concentration of about 100 milligrams per liter (mg/L) each.

To assess the ability of bioaugmentation to improve the rate and extent of TCE dechlorination to ethene, an additional set of triplicate MEAL microcosms was constructed and bioaugmented with KB-1™, a natural (i.e., not genetically modified), non-pathogenic dehalorespiring microbial consortia. This set of

microcosms was bioaugmented with KB-1™ (1 mL of culture) on 8 May 2003 (Day 35), following development of appropriate reducing redox conditions in the microcosms.

Table 1 summarizes the details of microcosm construction and amendments for the various treatment and control microcosms.

2.3 Microcosm Sampling and Analysis

Groundwater samples were collected from the various control and treatment microcosms on a weekly to bi-weekly basis for analysis of VOCs, headspace gases (e.g., ethene and methane), selected electron donors (directly for methanol, ethanol, acetate, lactate) and inorganic anions (chloride, nitrate, nitrite, sulphate and perchlorate). Microcosms were sampled using gas-tight 1.0 mL glass Hamilton syringes. Separate sets of syringes were used for bioaugmented and non-bioaugmented treatments, to reduce the potential for transfer of KB-1™ organisms to non-bioaugmented treatments. Syringes were cleaned with acidified water (pH 2-3) and rinsed 10 times with deionized water between samples, to ensure that VOCs and microorganisms were not transferred between different samples or treatments. Descriptions of the analytical methods employed by the biotreatability laboratory are provided in Appendix A.

3. RESULTS AND DISCUSSION

The following sections present the results of the biotreatability study. Section 3.1 discusses results for the sterile and intrinsic control microcosms; Section 3.2 discusses the results for the electron donor amended microcosms and Section 3.3 discusses the results for the KB-1 bioaugmented microcosms.

Figures 1 through 4 show the fate of the TCE and associated degradation products in each of the treatment and control microcosms over the incubation period for the study. All VOC concentrations are graphed in units of micromoles per microcosm bottle (µmol/bottle) to demonstrate mass balances on a molar basis (i.e., 1 micromole [µmol] of TCE is dechlorinated to 1 µmol of ethene). Table 2A provides the all the VOC data for the controls and treatments.

Figures 5 through 8 show the fate of perchlorate and the major anions in each of the treatment and control microcosms over the incubation period for the study. All perchlorate and anion concentrations are graphed in units of mg/L. Table 2B provides all the perchlorate and anion data.

3.1 Sterile and Intrinsic Controls

As expected, TCE and cis-1,2-dichloroethene (cis-DCE) concentrations in the Sterile Control microcosms remained relatively stable over the incubation period, showing no decline in TCE and cis-DCE or increase in dechlorination intermediates or end products (e.g., vinyl chloride [VC] or ethene) (Figures 1a and 1b). As well, perchlorate concentrations remained stable through out the incubation period. Furthermore, analytical data provided in Table 2A shows no methane production that would indicate microbial activity in these microcosms. These results confirm that any perchlorate, TCE and/or cis-DCE mass losses in the treatment microcosms result from biodegradation promoted by electron donor addition and/or bioaugmentation, and are not due to abiotic or experimental losses (e.g., sorption or loss through microcosm closures).

TCE and cis-1,2-DCE concentrations have also remained stable in the Anaerobic Intrinsic Control microcosms over 74 days of incubation, suggesting that the rate and extent of intrinsic biodegradation activity at the site may be low. As well chloride and sulphate concentrations remained stable over the 74 days. Perchlorate concentrations degraded by 20 days suggesting that there is sufficient electron donor and the proper indigenous bacteria population is present to degrade perchlorate at the site.

3.2 Electron Donor Treatments

Addition of soluble electron donor (MEAL) did not promote complete dechlorination of TCE to cis-1,2-DCE (Figure 3). The cis-DCE remained relatively constant through out the 74 day incubation period and there was no increase in dechlorination intermediates or end products. Perchlorate concentrations dropped rapidly with the addition of MEAL and dropped below 0.010 mg/L (method detection limit) on day 14.

3.3 Bioaugmented Treatments

Bioaugmentation of the KB1+MEAL microcosms took place on day 35 of the incubations. Following bioaugmentation with KB-1 on Day 35, cis-1,2-DCE concentrations declined from 35 mg/L to non-detect (<0.01 mg/L) by Day 64 (Figure 4). By day 74, the only product detected was ethene, thus showing the complete dechlorination of TCE to ethene in 74 days. Methane concentrations in these microcosms began to increase immediately after bioaugmentation and reached a maximum concentration of 5.13 mg/L on day 74. The presence of methane at this high of a concentration indicates strong microbial activity. Analytical data in the biotreatability report show that methanol and ethanol are being consumed in the MEAL+KB-1 treatments, indicating that the dechlorinating bacteria are using these electron donors in the dechlorinating

process. Perchlorate concentrations dropped rapidly with the addition of MEAL and dropped below 0.010 mg/L (method detection limit) on day 14.

4. CONCLUSIONS

Based on the results of this biotreatability study the following conclusions can be provided:

1. Complete degradation of perchlorate was observed in absence of added electron donor within 15 days of initiation of the test. Addition of soluble electron donor resulted in rapid degradation of perchlorate within 5 to 15 days.

2. The site groundwater and soil does not contain adequate naturally containing electron donors to promote rapid reductive dechlorination of TCE

3. The addition of soluble electron donor (MEAL) did not result in any cis-DCE dechlorination over the incubation period. This suggests that these electron donors alone may not be suitable to promote any indigenous *Dehalococcoides* that may be present at the site or a greater acclimation period is needed.

4. Complete and rapid dechlorination of TCE and cis-DCE via vinyl chloride to ethene was also observed in the bioaugmented microcosm amended with soluble electron donor (MEAL) and the natural, non-pathogenic microbial consortium KB-1.

TABLE 1: SUMMARY OF LABORATORY MICROCOSM CONTROLS & TREATMENTS.
Longhorn Army Ammunition Plant, Karnack, Texas

	Number of Microcosms
Controls	
Anaerobic Sterile Control (ANSC)	3
Anaerobic Intrinsic Control (ANAC)	3
Electron Donor Amended	
Methanol/ethanol/acetate/lactate (MEAL)	3
Bioaugmented	
MEAL + KB-1	3
Number of Microcosms	12

Detailed treatment table
Longhorn Army Ammunition Plant, Karnack, Texas

Treatment	Assigned bottle Number	Number of Microcosms	Sediment vol. in mL	Groundwater mL	Headspace mL	$HgCl_2$ mL	Na Azide mL	MeOH µL	EtOH µL	Lactate µL	Acetate µL	KB-1 mL
ANSC	1 to 3	3	30	150	75	2.8	0.5	*	*	*		
ANAC	4 to 6	3	30	150	75							
MEAL	7 to 9	3	30	150	75			20	20	250	280	
MEAL +KB 1	10 to 12	3	30	150	75			20	20	250	280	1

Notes:
* rep.1 of ANSC will be fed MEAL
Sterile controls: aquifer soils autoclaved, groundwater amended with mercuric chloride and sodium azide
Rezasurin added to rep 1 of each treatment.
$HgCl_2$: Mercuric Acid stock: add 2.8 mL of 2.7% stock soln' (final target concentration of 0.05%)
Na Azide: Sodium azide: add 0.5 mL of 5% stock solution (final target concentration of approximately 0.02%)
KB-1: Do NOT add for 2-3 weeks after time zero. Add 1 mL from actively degrading KB-1 bottle (record bottle ID in lab book) that has been purged to remove any VOCs and methane/ethene

Table 2A: VOC RAW DATA.
Longhorn Army Ammunition Plant, Karnack, Texas

Date	Day	Replicate	TCE	cis-1,2-DCE mg/L	trans-1,2-DCE mg/L	1,1-DCE mg/L	VC mg/L	Ethene mg/L	Total Ethenes µmol/L	Ethane mg/L	Methane mg/L	MeOH mg/L	EtOH mg/L
			Chlorinated Ethenes								Methane and Electron Donors		
Anaerobic Sterile Control													
03-Apr-03	0	ANSC-1	2.23	32.9	0.025	0.030	0.73	<0.01		<0.010	0.017	<1	<1.0
03-Apr-03	0	ANSC-2	3.01	39.1	0.025	0.040	0.96	<0.01		<0.010	0.019	<1	<1.0
03-Apr-03	0	ANSC-3	2.57	33.9	0.028	0.035	0.88	<0.01		<0.010	0.020	<1	<1.0
03-Apr-03	0	Average Concentration (mg/L)	2.60	35.29	0.03	0.03	0.86	0.00		0.00	0.02	0.00	0.00
03-Apr-03	0	Standard Deviation (mg/L)	3.9E-01	3.3E+00	1.8E-03	5.2E-03	1.2E-01	0.0E+00		0.0E+00	1.6E-03	0.0E+00	0.0E+00
03-Apr-03	**0**	**Average Concentration (umol)**	**3.92**	**65.9**	**0.048**	**0.061**	**3.36**	**0.00**	**7.3E+01**	**0**	**3.27**	**0**	**0**
09-Apr-03	6	ANSC-1	3.06	38.6	0.023	0.048	1.05	<0.01		<0.010	0.023	<1	<1
09-Apr-03	6	ANSC-2	2.90	37.8	0.022	0.044	0.98	<0.01		<0.010	0.019	<1	<1
09-Apr-03	6	ANSC-3	2.84	36.1	0.024	0.040	0.98	<0.01		<0.010	0.022	<1	<1
09-Apr-03	6	Average Concentration (mg/L)	2.93	37.50	0.02	0.04	1.00	0.00		0.00	0.02	0.00	0.00
09-Apr-03	6	Standard Deviation (mg/L)	1.1E-01	1.3E+00	1.0E-03	4.0E-03	4.0E-02	0.0E+00		0.0E+00	2.0E-03	0.0E+00	0.0E+00
09-Apr-03	**6**	**Average Concentration (umol)**	**4.42**	**70.0**	**0.042**	**0.077**	**3.93**	**0.00**	**7.8E+01**	**0**	**3.86**	**0**	**0**
17-Apr-03	14	ANSC-1	2.62	34.8	0.024	0.041	0.88	<0.01		<0.010	0.017	<1	<1
17-Apr-03	14	ANSC-2	2.70	35.9	0.019	0.036	0.89	<0.01		<0.010	0.017	<1	<1
17-Apr-03	14	ANSC-3	2.62	34.3	0.021	0.037	0.89	<0.01		<0.010	0.018	<1	<1
17-Apr-03	14	Average Concentration (mg/L)	2.65	34.99	0.02	0.04	0.89	0.00		0.00	0.02	0.00	0.00
17-Apr-03	14	Standard Deviation (mg/L)	4.7E-02	8.2E-01	2.5E-03	2.9E-03	5.8E-03	0.0E+00		0.0E+00	6.7E-04	0.0E+00	0.0E+00
17-Apr-03	**14**	**Average Concentration (umol)**	**3.99**	**65.3**	**0.039**	**0.066**	**3.48**	**0.00**	**7.3E+01**	**0**	**3.07**	**0**	**0**
25-Apr-03	22	ANSC-1	2.71	35.4	0.018	0.031	0.89	<0.01		<0.010	0.017	<1	<1
25-Apr-03	22	ANSC-2	2.50	32.9	0.020	0.034	0.82	<0.01		<0.010	0.013	<1	<1
25-Apr-03	22	ANSC-3	2.72	35.4	0.019	0.038	0.89	<0.01		<0.010	0.017	<1	<1
25-Apr-03	22	Average Concentration (mg/L)	2.64	34.57	0.02	0.03	0.87	0.00		0.00	0.02	0.00	0.00
25-Apr-03	22	Standard Deviation (mg/L)	1.2E-01	1.4E+00	9.4E-04	3.4E-03	4.0E-02	0.0E+00		0.0E+00	2.5E-03	0.0E+00	0.0E+00
25-Apr-03	**22**	**Average Concentration (umol)**	**3.98**	**64.5**	**0.035**	**0.060**	**3.40**	**0.00**	**7.2E+01**	**0**	**2.76**	**0**	**0**
01-May-03	28	ANSC-1	2.77	36.2	0.026	0.040	0.91	<0.01		<0.010	0.021	<1	6
01-May-03	28	ANSC-2	2.64	36.2	0.023	0.030	0.78	<0.01		<0.010	0.013	<1	<1
01-May-03	28	ANSC-3	2.69	35.2	0.019	0.036	0.88	<0.01		<0.010	0.020	<1	<1
01-May-03	28	Average Concentration (mg/L)	2.70	35.89	0.02	0.04	0.86	0.00		0.00	0.02	0.00	1.90
01-May-03	28	Standard Deviation (mg/L)	6.2E-02	5.9E-01	3.2E-03	4.7E-03	6.8E-02	0.0E+00		0.0E+00	4.3E-03	0.0E+00	3.3E+00
01-May-03	**28**	**Average Concentration (umol)**	**4.07**	**67.0**	**0.041**	**0.062**	**3.36**	**0.00**	**7.5E+01**	**0**	**3.16**	**0**	**6**
14-May-03	41	ANSC-1	2.69	36.6	0.022	0.028	0.85	<0.01		<0.010	0.015	<1	6
14-May-03	41	ANSC-2	2.64	36.5	0.022	0.038	0.82	<0.01		<0.010	0.015	<1	6
14-May-03	41	ANSC-3	2.56	34.9	0.028	0.037	0.79	<0.01		<0.010	0.014	<1	7
14-May-03	41	Average Concentration (mg/L)	2.63	36.00	0.02	0.03	0.82	0.00		0.00	0.01	0.00	6.02
14-May-03	41	Standard Deviation (mg/L)	6.9E-02	9.5E-01	3.6E-03	5.3E-03	3.0E-02	0.0E+00		0.0E+00	6.0E-04	0.0E+00	7.1E-01
14-May-03	**41**	**Average Concentration (umol)**	**3.96**	**67.2**	**0.044**	**0.060**	**3.21**	**0.00**	**7.4E+01**	**0**	**2.63**	**0**	**20**
28-May-03	55	ANSC-1	2.46	33.4	<0.01	0.029	0.78	<0.01		<0.010	0.014	<1	<1
28-May-03	55	ANSC-2	2.10	29.5	<0.01	<0.01	0.63	<0.01		<0.010	0.010	<1	<1
28-May-03	55	ANSC-3	2.54	34.1	<0.01	0.119	0.79	<0.01		<0.010	0.015	<1	<1
28-May-03	55	Average Concentration (mg/L)	2.37	32.33	0.00	0.05	0.73	0.00		0.00	0.01	0.00	0.00
28-May-03	55	Standard Deviation (mg/L)	2.3E-01	2.5E+00	0.0E+00	6.2E-02	9.0E-02	0.0E+00		0.0E+00	2.6E-03	0.0E+00	0.0E+00
28-May-03	**55**	**Average Concentration (umol)**	**3.57**	**60.4**	**0.000**	**0.086**	**2.87**	**0.00**	**6.7E+01**	**0**	**2.33**	**0**	**0**

Table 2A: VOC RAW DATA.
Longhorn Army Ammunition Plant, Karnack, Texas

			Chlorinated Ethenes								Methane and Electron Donors		
Date	**Day**	**Replicate**	**TCE**	**cis-1,2-DCE mg/L**	**trans-1,2-DCE mg/L**	**1,1-DCE mg/L**	**VC mg/L**	**Ethene mg/L**	**Total Ethenes µmol/L**	**Ethane mg/L**	**Methane mg/L**	**MeOH mg/L**	**EtOH mg/L**
16-Jun-03	74	ANSC-1	2.57	34.9	0.027	0.037	0.78	<0.01		<0.010	0.015	<1	6
16-Jun-03	74	ANSC-2	2.43	34.3	0.026	0.034	0.71	<0.01		<0.010	0.012	<1	6
16-Jun-03	74	ANSC-3	2.55	34.6	0.025	0.032	0.77	<0.01		<0.010	0.014	<1	7
16-Jun-03	74	Average Concentration (mg/L)	2.52	34.56	0.03	0.03	0.75	0.00		0.00	0.01	0.00	6.30
16-Jun-03	74	Standard Deviation (mg/L)	7.6E-02	3.1E-01	9.7E-04	2.5E-03	3.8E-02	0.0E+00		0.0E+00	1.7E-03	0.0E+00	4.6E-01
16-Jun-03	**74**	**Average Concentration (umol)**	**3.79**	**64.5**	**0.047**	**0.060**	**2.95**	**0.00**	**7.1E+01**	**0**	**2.48**	**0**	**21**
Anaerobic Intrinsic Control													
03-Apr-03	0	ANAC-1	2.94	34.5	0.026	0.032	0.78	<0.01		<0.010	0.013	<1	<1
03-Apr-03	0	ANAC-2	2.96	34.7	0.027	0.036	0.87	<0.01		<0.010	0.015	<1	<1
03-Apr-03	0	ANAC-3	3.85	41.4	0.026	0.048	1.13	<0.01		<0.010	0.023	<1	<1
03-Apr-03	0	Average Concentration (mg/L)	3.25	36.87	0.03	0.04	0.93	0.00		0.00	0.02	0.00	0.00
03-Apr-03	0	Standard Deviation (mg/L)	5.2E-01	3.9E+00	5.3E-04	8.5E-03	1.8E-01	0.0E+00		0.0E+00	5.4E-03	0.0E+00	0.0E+00
03-Apr-03	**0**	**Average Concentration (umol)**	**4.89**	**68.8**	**0.049**	**0.067**	**3.64**	**0.00**	**7.7E+01**	**0**	**3.09**	**0**	**0**
09-Apr-03	6	ANAC-1	2.92	33.2	0.024	0.037	0.78	<0.01		<0.010	0.015	<1	<1
09-Apr-03	6	ANAC-2	3.13	36.0	0.026	0.047	0.93	<0.01		<0.010	0.017	<1	<1
09-Apr-03	6	ANAC-3	3.83	40.2	0.028	0.051	1.08	<0.01		<0.010	0.024	<1	<1
09-Apr-03	6	Average Concentration (mg/L)	3.29	36.47	0.03	0.05	0.93	0.00		0.00	0.02	0.00	0.00
09-Apr-03	6	Standard Deviation (mg/L)	4.8E-01	3.5E+00	2.3E-03	7.2E-03	1.5E-01	0.0E+00		0.0E+00	4.4E-03	0.0E+00	0.0E+00
09-Apr-03	**6**	**Average Concentration (umol)**	**4.96**	**68.1**	**0.048**	**0.079**	**3.65**	**0.00**	**7.7E+01**	**0**	**3.36**	**0**	**0**
17-Apr-03	14	ANAC-1	2.68	31.3	0.026	0.036	0.71	<0.01		<0.010	0.011	<1	<1
17-Apr-03	14	ANAC-2	2.55	31.7	0.025	0.034	0.68	<0.01		<0.010	0.010	<1	<1
17-Apr-03	14	ANAC-3	3.53	36.9	0.031	0.049	0.95	<0.01		<0.010	0.019	<1	<1
17-Apr-03	14	Average Concentration (mg/L)	2.92	33.29	0.03	0.04	0.78	0.00		0.00	0.01	0.00	0.00
17-Apr-03	14	Standard Deviation (mg/L)	5.3E-01	3.1E+00	3.4E-03	8.0E-03	1.4E-01	0.0E+00		0.0E+00	5.3E-03	0.0E+00	0.0E+00
17-Apr-03	**14**	**Average Concentration (umol)**	**4.40**	**62.2**	**0.050**	**0.070**	**3.05**	**0.00**	**7.0E+01**	**0**	**2.40**	**0**	**0**
25-Apr-03	22	ANAC-1	2.58	30.2	0.024	0.036	0.67	<0.01		<0.010	0.009	<1	<1
25-Apr-03	22	ANAC-2	2.80	33.2	0.026	0.039	0.77	<0.01		<0.010	0.011	<1	<1
25-Apr-03	22	ANAC-3	3.60	37.2	0.030	0.049	0.93	<0.01		<0.010	0.016	<1	<1
25-Apr-03	22	Average Concentration (mg/L)	2.99	33.54	0.03	0.04	0.79	0.00		0.00	0.01	0.00	0.00
25-Apr-03	22	Standard Deviation (mg/L)	5.4E-01	3.5E+00	2.8E-03	6.9E-03	1.3E-01	0.0E+00		0.0E+00	3.9E-03	0.0E+00	0.0E+00
25-Apr-03	**22**	**Average Concentration (umol)**	**4.51**	**62.6**	**0.049**	**0.072**	**3.10**	**0.00**	**7.0E+01**	**0**	**2.11**	**0**	**0**
01-May-03	28	ANAC-1	2.76	32.8	0.023	0.040	0.73	<0.01		<0.010	0.013	<1	<1
01-May-03	28	ANAC-2	2.83	34.1	0.022	0.042	0.79	<0.01		<0.010	0.014	<1	<1
01-May-03	28	ANAC-3	3.84	40.0	0.034	0.052	0.96	<0.01		<0.010	0.018	<1	<1
01-May-03	28	Average Concentration (mg/L)	3.15	35.62	0.03	0.04	0.83	0.00		0.00	0.01	0.00	0.00
01-May-03	28	Standard Deviation (mg/L)	6.0E-01	3.8E+00	6.5E-03	6.2E-03	1.2E-01	0.0E+00		0.0E+00	3.1E-03	0.0E+00	0.0E+00
01-May-03	**28**	**Average Concentration (umol)**	**4.74**	**66.5**	**0.048**	**0.078**	**3.24**	**0.00**	**7.5E+01**	**0**	**2.66**	**0**	**0**
14-May-03	41	ANAC-1	2.60	33.0	0.025	0.041	0.71	<0.01		<0.010	0.010	<1	<1
14-May-03	41	ANAC-2	2.88	34.7	0.025	0.044	0.81	<0.01		<0.010	0.013	<1	<1
14-May-03	41	ANAC-3	3.83	38.8	0.036	0.052	0.96	<0.01		<0.010	0.026	<1	<1
14-May-03	41	Average Concentration (mg/L)	3.10	35.52	0.03	0.05	0.83	0.00		0.00	0.02	0.00	0.00
14-May-03	41	Standard Deviation (mg/L)	6.4E-01	3.0E+00	6.0E-03	5.8E-03	1.3E-01	0.0E+00		0.0E+00	8.3E-03	0.0E+00	0.0E+00
14-May-03	**41**	**Average Concentration (umol)**	**4.67**	**66.3**	**0.052**	**0.080**	**3.24**	**0.00**	**7.4E+01**	**0**	**2.88**	**0**	**0**

Table 2A: VOC RAW DATA.
Longhorn Army Ammunition Plant, Karnack, Texas

			Chlorinated Ethenes							Methane and Electron Donors			
Date	**Day**	**Replicate**	**TCE**	**cis-1,2-DCE mg/L**	**trans-1,2-DCE mg/L**	**1,1-DCE mg/L**	**VC mg/L**	**Ethene mg/L**	**Total Ethenes μmol/L**	**Ethane mg/L**	**Methane mg/L**	**MeOH mg/L**	**EtOH mg/L**
28-May-03	55	ANAC-1	2.46	32.0	<0.01	0.215	0.67	<0.01		<0.010	0.009	<1	<1
28-May-03	55	ANAC-2	2.77	34.2	0.088	0.258	0.76	<0.01		<0.010	0.010	<1	<1
28-May-03	55	ANAC-3	3.34	33.9	0.087	0.132	0.82	<0.01		<0.010	0.015	<1	<1
28-May-03	55	Average Concentration (mg/L)	2.86	33.37	0.06	0.20	0.75	0.00		0.00	0.01	0.00	0.00
28-May-03	55	Standard Deviation (mg/L)	4.5E-01	1.2E+00	5.1E-02	6.4E-02	7.6E-02	0.0E+00		0.0E+00	3.2E-03	0.0E+00	0.0E+00
28-May-03	**55**	**Average Concentration (umol)**	**4.30**	**62.3**	**0.107**	**0.353**	**2.94**	**0.00**	**7.0E+01**	**0**	**2.03**	**0**	**0**
16-Jun-03	74	ANAC-1	2.32	32.7	0.025	0.037	0.68	<0.01		<0.010	0.013	<1	<1
16-Jun-03	74	ANAC-2	2.77	34.0	0.029	0.039	0.77	<0.01		<0.010	0.013	<1	<1
16-Jun-03	74	ANAC-3	3.73	38.5	0.045	0.047	0.93	<0.01		<0.010	0.018	<1	<1
16-Jun-03	74	Average Concentration (mg/L)	2.94	35.06	0.03	0.04	0.80	0.00		0.00	0.01	0.00	0.00
16-Jun-03	74	Standard Deviation (mg/L)	7.2E-01	3.0E+00	1.1E-02	5.1E-03	1.2E-01	0.0E+00		0.0E+00	3.1E-03	0.0E+00	0.0E+00
16-Jun-03	**74**	**Average Concentration (umol)**	**4.43**	**65.5**	**0.060**	**0.072**	**3.12**	**0.00**	**7.3E+01**	**0**	**2.64**	**0**	**0**
Methanol, Ethanol, Acetate, Lactate													
03-Apr-03	0	MEAL-1	2.80	33.0	0.023	0.032	0.78	<0.01		<0.010	0.014	<1	<1
03-Apr-03	0	MEAL-2	3.00	35.1	0.017	0.035	0.87	<0.01		<0.010	0.010	<1	<1
03-Apr-03	0	MEAL-3	3.16	35.9	0.023	0.038	0.94	<0.01		<0.010	0.020	<1	<1
03-Apr-03	0	Average Concentration (mg/L)	2.99	34.66	0.02	0.03	0.86	0.00		0.00	0.01	0.00	0.00
03-Apr-03	0	Standard Deviation (mg/L)	1.8E-01	1.5E+00	3.5E-03	2.9E-03	8.0E-02	0.0E+00		0.0E+00	5.0E-03	0.0E+00	0.0E+00
03-Apr-03	**0**	**Average Concentration (umol)**	**4.51**	**64.7**	**0.038**	**0.061**	**3.38**	**0.00**	**7.3E+01**	**0**	**2.62**	**0**	**0**
09-Apr-03	6	MEAL-1	2.86	33.0	0.034	NA	0.79	<0.01		<0.010	0.016	107	112
09-Apr-03	6	MEAL-2	3.35	37.0	0.026	NA	0.97	<0.01		<0.010	0.020	110	86
09-Apr-03	6	MEAL-3	3.20	35.7	0.027	NA	0.96	<0.01		<0.010	0.020	110	90
09-Apr-03	6	Average Concentration (mg/L)	3.14	35.23	0.03	0.00	0.91	0.00		0.00	0.02	109.00	96.11
09-Apr-03	6	Standard Deviation (mg/L)	2.5E-01	2.0E+00	4.4E-03	0.0E+00	1.0E-01	0.0E+00		0.0E+00	2.7E-03	1.7E+00	1.4E+01
09-Apr-03	**6**	**Average Concentration (umol)**	**4.73**	**65.8**	**0.053**	**0.000**	**3.55**	**0.00**	**7.4E+01**	**0**	**3.37**	**510**	**313**
17-Apr-03	14	MEAL-1	2.30	32.7	0.049	0.035	0.72	<0.01		<0.010	0.012	100	8
17-Apr-03	14	MEAL-2	3.15	35.4	0.056	0.037	0.90	<0.01		<0.010	0.018	105	14
17-Apr-03	14	MEAL-3	2.74	31.7	0.045	0.077	0.78	<0.01		<0.010	0.013	104	62
17-Apr-03	14	Average Concentration (mg/L)	2.73	33.28	0.05	0.05	0.80	0.00		0.00	0.01	102.96	27.65
17-Apr-03	14	Standard Deviation (mg/L)	4.3E-01	1.9E+00	5.4E-03	2.3E-02	8.9E-02	0.0E+00		0.0E+00	3.2E-03	2.9E+00	3.0E+01
17-Apr-03	**14**	**Average Concentration (umol)**	**4.12**	**62.1**	**0.091**	**0.087**	**3.13**	**0.00**	**7.0E+01**	**0**	**2.51**	**482**	**90**
23-Apr-03	**20**	**MEAL**	**fed 20 μL EtOH to reps 1 and 2**										
25-Apr-03	22	MEAL-1	0.01	35.5	0.051	0.037	0.71	<0.01		<0.010	0.009	<1	36
25-Apr-03	22	MEAL-2	2.93	34.1	0.052	0.040	0.84	<0.01		<0.010	0.014	<1	22
25-Apr-03	22	MEAL-3	2.95	33.9	0.064	0.041	0.84	<0.01		<0.010	0.014	<1	28
25-Apr-03	22	Average Concentration (mg/L)	1.96	34.47	0.06	0.04	0.80	0.00		0.00	0.01	0.00	28.72
25-Apr-03	22	Standard Deviation (mg/L)	1.7E+00	8.6E-01	7.0E-03	2.0E-03	7.6E-02	0.0E+00		0.0E+00	2.9E-03	0.0E+00	6.9E+00
25-Apr-03	**22**	**Average Concentration (umol)**	**2.96**	**64.4**	**0.101**	**0.069**	**3.12**	**0.00**	**7.1E+01**	**0**	**2.27**	**0**	**94**

Table 2A: VOC RAW DATA.
Longhorn Army Ammunition Plant, Karnack, Texas

			Chlorinated Ethenes								Methane and Electron Donors		
Date	**Day**	**Replicate**	**TCE**	**cis-1,2-DCE mg/L**	**trans-1,2-DCE mg/L**	**1,1-DCE mg/L**	**VC mg/L**	**Ethene mg/L**	**Total Ethenes µmol/L**	**Ethane mg/L**	**Methane mg/L**	**MeOH mg/L**	**EtOH mg/L**
28-Apr-03	**25**	**MEAL**	**fed 20 µL MeOH and 20 µL EtOH to all 3 reps**										
01-May-03	28	MEAL-1	<0.01	35.3	0.049	0.036	0.69	<0.01		<0.010	0.012	102	99
01-May-03	28	MEAL-2	2.79	33.6	0.049	0.038	0.79	<0.01			0.016	58	45
01-May-03	28	MEAL-3	2.65	31.5	0.029	0.041	0.74	<0.01		<0.010	0.013	94	99
01-May-03	28	Average Concentration (mg/L)	1.81	33.46	0.04	0.04	0.74	0.00		0.00	0.01	84.65	81.09
01-May-03	28	Standard Deviation (mg/L)	1.6E+00	1.9E+00	1.2E-02	3.0E-03	5.3E-02	0.0E+00		0.0E+00	1.8E-03	2.4E+01	3.1E+01
01-May-03	**28**	**Average Concentration (umol)**	**2.73**	**62.5**	**0.077**	**0.067**	**2.90**	**0.00**	**6.8E+01**	**0**	**2.42**	**396**	**264**
08-May-03	**25**	**MEAL**	**fed 10 µL MeOH and 10 µL EtOH to rep 2 only**										
14-May-03	41	MEAL-1	0.04	35.2	0.059	0.037	0.67	<0.01		<0.010	0.009	<1	112
14-May-03	41	MEAL-2	<0.01	36.7	0.036	0.045	0.79	<0.01			0.013	57	57
14-May-03	41	MEAL-3	2.71	33.4	0.042	0.042	0.84	<0.01		<0.010	0.015	<1	262
14-May-03	41	Average Concentration (mg/L)	0.92	35.07	0.05	0.04	0.76	0.00		0.00	0.01	18.88	143.61
14-May-03	41	Standard Deviation (mg/L)	1.6E+00	1.7E+00	1.2E-02	4.0E-03	8.7E-02	0.0E+00		0.0E+00	3.2E-03	3.3E+01	1.1E+02
14-May-03	**41**	**Average Concentration (umol)**	**1.38**	**65.5**	**0.084**	**0.072**	**3.00**	**0.00**	**7.0E+01**	**0**	**2.18**	**88**	**468**
15-May-03	**42**	**MEAL**	**fed 20 µL MeOH reps 2 and 3, fed 10 µL MeOH and 10 µL EtOH to rep 2**										
28-May-03	55	MEAL-1	<0.01	34.1	0.035	1.041	0.67	<0.01		<0.010	0.015	<1	<1
28-May-03	55	MEAL-2	<0.01	36.8	0.040	0.635	0.80	<0.01			0.014	<1	<1
28-May-03	55	MEAL-3	2.77	32.4	0.029	2.121	0.81	<0.01		<0.010	0.014	128	<1
28-May-03	55	Average Concentration (mg/L)	0.92	34.43	0.03	1.27	0.76	0.00		0.00	0.01	42.50	0.00
28-May-03	55	Standard Deviation (mg/L)	1.6E+00	2.2E+00	5.5E-03	7.7E-01	8.1E-02	0.0E+00		0.0E+00	5.8E-04	7.4E+01	0.0E+00
28-May-03	**55**	**Average Concentration (umol)**	**1.39**	**64.3**	**0.063**	**2.212**	**2.98**	**0.00**	**7.1E+01**	**0**	**2.56**	**199**	**0**
30-May-03	**57**	**MEAL**	**fed 20 µL EtOH to rep 3, fed 20 µL MeOH and 20 µL EtOH to reps 1 and 2**										
16-Jun-03	74	MEAL-1	0.04	33.3	0.036	0.031	0.55	<0.01		<0.010	0.013	<1	127
16-Jun-03	74	MEAL-2	<0.01	38.2	0.032	0.045	0.82	<0.01			0.017	<1	76
16-Jun-03	74	MEAL-3	2.82	34.0	0.030	0.040	0.84	<0.01		<0.010	0.016	99	95
16-Jun-03	74	Average Concentration (mg/L)	0.95	35.17	0.03	0.04	0.74	0.00		0.00	0.02	33.17	99.21
16-Jun-03	74	Standard Deviation (mg/L)	1.6E+00	2.6E+00	2.8E-03	6.9E-03	1.6E-01	0.0E+00		0.0E+00	2.4E-03	5.7E+01	2.6E+01
16-Jun-03	**74**	**Average Concentration (umol)**	**1.44**	**65.7**	**0.059**	**0.067**	**2.89**	**0.00**	**7.0E+01**	**0**	**2.73**	**155**	**323**
Methanol, Ethanol, Acetate, Lactate and KB 1													
03-Apr-03	0	MEA+KB 1-1	3.61	39.4	0.025	0.045	1.06	<0.01		<0.010	0.034	<1	<1
03-Apr-03	0	MEA+KB 1-2	3.28	37.3	0.023	0.040	0.94	<0.01		<0.010	0.019	<1	<1
03-Apr-03	0	MEA+KB 1-3	3.36	36.5	0.026	0.039	0.92	<0.01		<0.010	0.014	<1	<1
03-Apr-03	0	Average Concentration (mg/L)	3.42	37.72	0.02	0.04	0.97	0.00		0.00	0.02	0.00	0.00
03-Apr-03	0	Standard Deviation (mg/L)	1.7E-01	1.5E+00	1.6E-03	3.4E-03	7.5E-02	0.0E+00		0.0E+00	1.0E-02	0.0E+00	0.0E+00
03-Apr-03	**0**	**Average Concentration (umol)**	**5.15**	**70.4**	**0.045**	**0.073**	**3.82**	**0.00**	**8.0E+01**	**0**	**4.02**	**0**	**0**
09-Apr-03	6	MEA+KB 1-1	3.68	39.4	0.027	NA	1.04	<0.01		<0.010	0.020	110	111
09-Apr-03	6	MEA+KB 1-2	3.20	36.7	0.027	NA	0.92	<0.01		<0.010	0.017	118	114
09-Apr-03	6	MEA+KB 1-3	3.81	40.7	0.032	NA	1.01	<0.01		<0.010	0.017	119	100
09-Apr-03	6	Average Concentration (mg/L)	3.56	38.93	0.03	0.00	0.99	0.00		0.00	0.02	115.67	108.32
09-Apr-03	6	Standard Deviation (mg/L)	3.2E-01	2.0E+00	3.1E-03	0.0E+00	6.2E-02	0.0E+00		0.0E+00	2.0E-03	4.9E+00	7.6E+00
09-Apr-03	**6**	**Average Concentration (umol)**	**5.37**	**72.7**	**0.052**	**0.000**	**3.88**	**0.00**	**8.2E+01**	**0**	**3.24**	**542**	**353**

Table 2A: VOC RAW DATA
Longhorn Army Ammunition Plant, Karnack, Texas

Date	Day	Replicate	Chlorinated Ethenes TCE	cis-1,2-DCE mg/L	trans-1,2-DCE mg/L	1,1-DCE mg/L	VC mg/L	Ethene mg/L	Total Ethenes µmol/L	Ethane mg/L	Methane and Electron Donors Methane mg/L	MeOH mg/L	EtOH mg/L
17-Apr-03	14	MEA+KB 1-1	0.04	39.0	0.085	0.046	0.92	<0.01		<0.010	0.019	99	8
17-Apr-03	14	MEA+KB 1-2	<0.01	36.8	0.056	0.044	0.85	<0.01		<0.010	0.016	93	6
17-Apr-03	14	MEA+KB 1-3	<0.01	40.5	0.076	0.038	0.90	<0.01		<0.010	0.014	107	5
17-Apr-03	14	Average Concentration (mg/L)	0.01	38.75	0.07	0.04	0.89	0.00		0.00	0.02	100.04	6.30
17-Apr-03	14	Standard Deviation (mg/L)	2.4E-02	1.8E+00	1.5E-02	4.0E-03	3.4E-02	0.0E+00		0.0E+00	2.7E-03	6.9E+00	1.5E+00
17-Apr-03	**14**	**Average Concentration (umol)**	**0.02**	**72.3**	**0.132**	**0.075**	**3.50**	**0.00**	**7.6E+01**	**0**	**2.90**	**468**	**21**
23-Apr-03	**20**	**MEAL**	**fed 20 µL EtOH to all 3 reps**										
25-Apr-03	22	MEA+KB 1-1	0.01	35.0	0.046	0.041	0.76	<0.01		<0.010	0.012	<1	12
25-Apr-03	22	MEA+KB 1-2	<0.01	33.3	0.023	0.038	0.72	<0.01		<0.010	0.011	<1	34
25-Apr-03	22	MEA+KB 1-3	<0.01	37.3	0.056	0.040	0.81	<0.01		<0.010	0.011	<1	12
25-Apr-03	22	Average Concentration (mg/L)	0.00	35.22	0.04	0.04	0.77	0.00		0.00	0.01	0.00	19.29
25-Apr-03	22	Standard Deviation (mg/L)	8.3E-03	2.0E+00	1.7E-02	1.5E-03	4.5E-02	0.0E+00		0.0E+00	4.9E-04	0.0E+00	1.3E+01
25-Apr-03	**22**	**Average Concentration (umol)**	**0.01**	**65.8**	**0.076**	**0.069**	**3.01**	**0.00**	**6.9E+01**	**0**	**2.01**	**0**	**63**
28-Apr-03	**25**	**MEAL**	**fed 20 µL MeOH and 20 µL EtOH to all 3 reps**										
01-May-03	28	MEA+KB 1-1	<0.01	37.0	0.044	0.048	0.83	<0.01		<0.010	0.016	19	21
01-May-03	28	MEA+KB 1-2	<0.01	36.1	0.058	0.041	0.79	<0.01		<0.010	0.016	103	130
01-May-03	28	MEA+KB 1-3	<0.01	38.6	0.053	0.043	0.80	<0.01		<0.010	0.012	30	43
01-May-03	28	Average Concentration (mg/L)	0.00	37.24	0.05	0.04	0.81	0.00		0.00	0.01	50.39	64.93
01-May-03	28	Standard Deviation (mg/L)	0.0E+00	1.2E+00	7.2E-03	3.8E-03	2.4E-02	0.0E+00		0.0E+00	2.1E-03	4.6E+01	5.8E+01
01-May-03	**28**	**Average Concentration (umol)**	**0.00**	**69.5**	**0.094**	**0.077**	**3.17**	**0.00**	**7.3E+01**	**0**	**2.59**	**236**	**211**
08-May-03	**35**	MEAL	**1ml of KB-1 used to innoculate all MEA + KB-1 bottles**										
08-May-03	**35**	**MEAL**	**fed 20 µL MeOH to all 3 reps, fed 20 µL EtOH to rep 1 and 10 µL EtOH to rep 3**										
08-May-03	35	MEA+KB 1-1	<0.01	37.0	0.052	0.034	0.91	<0.01		<0.010	0.017	132	40
08-May-03	35	MEA+KB 1-2	0.03	35.2	0.026	0.044	0.83	<0.01		<0.010	0.017	134	152
08-May-03	35	MEA+KB 1-3	<0.01	36.6	0.029	0.042	0.83	<0.01		<0.010	0.015	129	58
08-May-03	35	Average Concentration (mg/L)	0.01	36.27	0.04	0.04	0.86	0.00		0.00	0.02	131.67	83.33
08-May-03	35	Standard Deviation (mg/L)	1.7E-02	9.5E-01	1.4E-02	5.3E-03	4.6E-02	0.0E+00		0.0E+00	1.1E-03	2.5E+00	6.0E+01
08-May-03	**35**	**Average Concentration (umol)**	**0.02**	**67.7**	**0.065**	**0.070**	**3.36**	**0.00**	**7.1E+01**	**0**	**2.90**	**616**	**271**
14-May-03	41	MEA+KB 1-1	<0.01	24.7	0.027	0.036	5.79	0.267		<0.010	0.059	88	34
14-May-03	41	MEA+KB 1-2	0.04	28.4	0.033	0.035	4.54	0.095		<0.010	0.064	69	139
14-May-03	41	MEA+KB 1-3	<0.01	22.7	0.028	0.028	6.96	0.414		<0.010	0.12	113	48
14-May-03	41	Average Concentration (mg/L)	0.01	25.27	0.03	0.03	5.76	0.26		0.00	0.08	90.00	73.57
14-May-03	41	Standard Deviation (mg/L)	2.1E-02	2.9E+00	3.3E-03	4.4E-03	1.2E+00	1.6E-01		0.0E+00	3.5E-02	2.2E+01	5.7E+01
14-May-03	**41**	**Average Concentration (umol)**	**0.02**	**47.2**	**0.054**	**0.058**	**22.59**	**11.43**	**8.1E+01**	**0**	**14.61**	**421**	**240**
15-May-03	**42**	**MEAL**	**fed 10 µL EtOH to reps 1 and 3**										
21-May-03	48	MEA+KB 1-1	<0.01	8.3	<0.01	0	7.57	0.647			0.209	<1	<1
21-May-03	48	MEA+KB 1-2	<0.01	13.7	0.024	1.001	7.12	0.370		<0.010	0.323	<1	<1
21-May-03	48	MEA+KB 1-3	<0.01	0.4	<0.01	0	2.13	1.85		<0.010	1.00	<1	<1
21-May-03	48	Average Concentration (mg/L)	0.00	7.47	0.01	0.33	5.61	0.96		0.00	0.51	0.00	0.00
21-May-03	48	Standard Deviation (mg/L)	0.0E+00	6.7E+00	1.4E-02	5.8E-01	3.0E+00	7.9E-01		0.0E+00	4.3E-01	0.0E+00	0.0E+00

Table 2A: VOC RAW DATA.
Longhorn Army Ammunition Plant, Karnack, Texas

			Chlorinated Ethenes								Methane and Electron Donors		
Date	**Day**	**Replicate**	**TCE**	**cis-1,2-DCE mg/L**	**trans-1,2-DCE mg/L**	**1,1-DCE mg/L**	**VC mg/L**	**Ethene mg/L**	**Total Ethenes µmol/L**	**Ethane mg/L**	**Methane mg/L**	**MeOH mg/L**	**EtOH mg/L**
22-May-03	**49**	**MEA+KB-1**	**fed 20 µL MeOH to all 3 reps**										
26-May-03	**54**	**MEA+KB-1**	**fed 20 µL MeOH to all 3 reprs**										
28-May-03	55	MEA+KB 1-1	<0.01	0.5	<0.01	0	2.53	1.83		<0.010	0.371	88	<1
28-May-03	55	MEA+KB 1-2	<0.01	4.9	<0.01	0	7.38	1.19		<0.010	0.642	94	<1
28-May-03	55	MEA+KB 1-3	<0.01	<0.01	<0.01	0	<0.01	1.69		<0.010	3.13	29	<1
28-May-03	55	Average Concentration (mg/L)	0.00	1.81	0.00	0.00	3.30	1.57		0.00	1.38	70.23	0.00
28-May-03	55	Standard Deviation (mg/L)	0.0E+00	2.7E+00	0.0E+00	0.0E+00	3.8E+00	3.3E-01		0.0E+00	1.5E+00	3.6E+01	0.0E+00
28-May-03	**55**	**Average Concentration (umol)**	**0.00**	**3.4**	**0.000**	**0.000**	**12.95**	**69.31**	**8.6E+01**	**0**	**247.28**	**329**	**0**
30-May-03	**54**	**MEA+KB-1**	**fed 20 µL EtOH to all 3 reps**										
06-Jun-03	64	MEA+KB 1-1	<0.01	<0.01	0.01	0.022	0.02	1.26		<0.010	1.62	<1	255
06-Jun-03	64	MEA+KB 1-2	<0.01	<0.01	0.013	0.016	0.04	1.52		<0.010	2.81	<1	112
06-Jun-03	64	MEA+KB 1-3	<0.01	<0.01	0.011	0.017	0.01	1.10		<0.010	4.765	<1	162
06-Jun-03	64	Average Concentration (mg/L)	0.00	0.00	0.01	0.02	0.02	1.29		0.00	3.07	0.00	176.45
06-Jun-03	64	Standard Deviation (mg/L)	0.0E+00	0.0E+00	1.5E-03	3.5E-03	1.7E-02	2.1E-01		0.0E+00	1.6E+00	0.0E+00	7.3E+01
06-Jun-03	**64**	**Average Concentration (umol)**	**0.00**	**0.0**	**0.021**	**0.032**	**0.09**	**57.12**	**5.7E+01**	**0**	**548.53**	**0**	**575**
08-Jun-03	**66**	**MEA+KB-1**	**fed 20 µL MEOH to all 3 reps, fed 20 µL EtOH to rep 3**										
16-Jun-03	74	MEA+KB 1-1	<0.01	<0.01	0.02	0.026	<0.01	1.58		<0.010	3.90	<1	284
16-Jun-03	74	MEA+KB 1-2	<0.01	<0.01	0.011	0.013	<0.01	1.63		<0.010	5.15	<1	163
16-Jun-03	74	MEA+KB 1-3	<0.01	<0.01	0.010	<0.01	<0.01	1.60		<0.010	6.34	<1	195
16-Jun-03	74	Average Concentration (mg/L)	0.00	0.00	0.01	0.01	0.00	1.60		0.00	5.13	0.00	214
16-Jun-03	74	Standard Deviation (mg/L)	0.0E+00	0.0E+00	2.6E-03	1.3E-02	0.0E+00	2.5E-02		0.0E+00	1.2E+00	0.0E+00	6.3E+01
16-Jun-03	**74**	**Average Concentration (umol)**	**0.00**	**0.0**	**0.022**	**0.022**	**0.00**	**70.82**	**7.1E+01**	**0**	**918.26**	**0**	**698**

Table 2B: PERCHLORATE AND GEOCHEMICAL RAW DATA.
Longhorn Army Ammunition Plant, Karnack, Texas

Date	Day	Replicate	perchlorate mg/L	acetate & lactate* mg/L	chloride mg/L	nitrite mg/L	nitrate mg/L	phosphate mg/L	sulphate mg/L
Anaerobic Sterile Control									
03-Apr-03	0	ANSC-1	0.561	<2.4	815	<0.5	26.5	<1	979
03-Apr-03	0	ANSC-2	0.501	<2.4	911	<0.5	17.1	<1	990
03-Apr-03	0	ANSC-3	0.500	<2.4	1144	<0.5	20.2	<1	1013
03-Apr-03	0	Standard Deviation (mg/L)	3.5E-02	0.0E+00	1.7E+02	0.0E+00	4.8E+00	0.0E+00	1.7E+01
03-Apr-03	**0**	**Average Concentration (mg/L)**	**0.52**	**0.00**	**956.67**	**0.00**	**21.28**	**0.00**	**994.00**
09-Apr-03	6	ANSC-1	0.615	<2.4	979	<0.5	25.1	<1	1034
09-Apr-03	6	ANSC-2	0.636	<2.4	973	<0.5	20.5	<1	1024
09-Apr-03	6	ANSC-3	0.606	<2.4	1008	<0.5	28.0	<1	1057
09-Apr-03	6	Standard Deviation (mg/L)	1.5E-02	0.0E+00	1.8E+01	0.0E+00	3.8E+00	0.0E+00	1.7E+01
09-Apr-03	**6**	**Average Concentration (mg/L)**	**0.62**	**<2.4**	**986.90**	**<0.5**	**24.55**	**<1**	**1038.33**
17-Apr-03	14	ANSC-1	0.798	<2.4	973	<0.5	24.9	<1	1134.461
17-Apr-03	14	ANSC-2	0.758	<2.4	958	<0.5	18.0	<1	1111
17-Apr-03	14	ANSC-3	0.714	<2.4	985	<0.5	19.3	<1	1134
17-Apr-03	14	Standard Deviation (mg/L)	4.2E-02	0.0E+00	1.4E+01	0.0E+00	3.6E+00	0.0E+00	1.3E+01
17-Apr-03	**14**	**Average Concentration (mg/L)**	**0.76**	**<2.4**	**972.04**	**<0.5**	**20.73**	**<1**	**1126.49**
25-Apr-03	22	ANSC-1	ND	405	946	<0.5	23.3	<1	979
25-Apr-03	22	ANSC-2	ND	<2.4	961	<0.5	16.7	<1	949
25-Apr-03	22	ANSC-3	ND	<2.4	960	<0.5	20.3	<1	918
25-Apr-03	22	Standard Deviation (mg/L)	0.0E+00	0.0E+00	8.5E+00	0.0E+00	3.3E+00	0.0E+00	3.1E+01
25-Apr-03	**22**	**Average Concentration (mg/L)**	**0.00**	**135.00**	**955.54**	**<0.5**	**20.11**	**<1**	**948.67**
01-May-03	28	ANSC-1	ND	365	976	<0.5	10.5	<1	921
01-May-03	28	ANSC-2	ND	<2.4	983	<0.5	11.2	<1	892
01-May-03	28	ANSC-3	ND	<2.4	976	<0.5	9.7	<1	884
01-May-03	28	Standard Deviation (mg/L)	0.0E+00	2.1E+02	4.1E+00	0.0E+00	7.2E-01	0.0E+00	1.9E+01
01-May-03	**28**	**Average Concentration (mg/L)**	**0.00**	**121.67**	**978.62**	**<0.5**	**10.48**	**<1**	**899.00**
14-May-03	41	ANSC-1	0.852	376	980	<0.5	9.8	<1	1069
14-May-03	41	ANSC-2	0.884	<2.4	1015	<0.5	11.3	<1	1109
14-May-03	41	ANSC-3	0.935	<2.4	998	<0.5	9.0	<1	1046
14-May-03	41	Standard Deviation (mg/L)	4.2E-02	2.2E+02	1.8E+01	0.0E+00	1.2E+00	0.0E+00	3.2E+01
14-May-03	**41**	**Average Concentration (mg/L)**	**0.89**	**125.33**	**997.67**	**<0.5**	**10.03**	**<1**	**1074.67**
28-May-03	55	ANSC-1	ND	377	1003	<0.5	7.9	<1	1146
28-May-03	55	ANSC-2	ND	<2.4	996	<0.5	8.7	<1	1179
28-May-03	55	ANSC-3	ND	<2.4	1023	<0.5	9.9	<1	1175
28-May-03	55	Standard Deviation (mg/L)	0.0E+00	2.2E+02	1.4E+01	0.0E+00	1.0E+00	0.0E+00	1.8E+01
28-May-03	**55**	**Average Concentration (mg/L)**	**0.00**	**125.67**	**1007.25**	**<0.5**	**8.83**	**<1**	**1166.67**
16-Jun-03	74	ANSC-1	ND	353	988	<0.5	7.2	<1	1163
16-Jun-03	74	ANSC-2	ND	<2.4	1018	<0.5	7.9	<1	1184
16-Jun-03	74	ANSC-3	ND	<2.4	995	<0.5	9.2	<1	1167
16-Jun-03	74	Standard Deviation (mg/L)	0.0E+00	2.0E+02	1.6E+01	0.0E+00	1.0E+00	0.0E+00	1.1E+01
16-Jun-03	**74**	**Average Concentration (mg/L)**	**0.00**	**117.67**	**1000.33**	**<0.5**	**8.10**	**<1**	**1171.33**

Table 2B: PERCHLORATE AND GEOCHEMICAL RAW DATA.
Longhorn Army Ammunition Plant, Karnack, Texas

Date	Day	Replicate	perchlorate mg/L	acetate & lactate* mg/L	chloride mg/L	nitrite mg/L	nitrate mg/L	phosphate mg/L	sulphate mg/L
Anaerobic Intrinsic Control									
03-Apr-03	0	ANAC-1	0.543	<2.4	810	<0.5	25.7	<1	983
03-Apr-03	0	ANAC-2	0.533	<2.4	812	<0.5	32.3	<1	992
03-Apr-03	0	ANAC-3	0.576	<2.4	754	<0.5	16.4	<1	999
03-Apr-03	0	Standard Deviation (mg/L)	2.3E-02	0.0E+00	3.3E+01	0.0E+00	8.0E+00	0.0E+00	8.0E+00
03-Apr-03	**0**	**Average Concentration (mg/L)**	**0.55**	**<2.4**	**792.10**	**<0.5**	**24.80**	**<1**	**991.33**
09-Apr-03	6	ANAC-1	<0.01	<2.4	652	<0.5	18.8	<1	934
09-Apr-03	6	ANAC-2	<0.01	<2.4	856	<0.5	30.6	<1	1069
09-Apr-03	6	ANAC-3	0.587	<2.4	793	<0.5	23.7	<1	1046
09-Apr-03	6	Standard Deviation (mg/L)	3.4E-01	0.0E+00	1.0E+02	0.0E+00	5.9E+00	0.0E+00	7.2E+01
09-Apr-03	**6**	**Average Concentration (mg/L)**	**0.20**	**<2.4**	**767.02**	**<0.5**	**24.39**	**<1**	**1016.33**
17-Apr-03	14	ANAC-1	<0.01	<2.4	753	<0.5	20.9	<1	979
17-Apr-03	14	ANAC-2	<0.01	<2.4	771	<0.5	5.0	<1	934
17-Apr-03	14	ANAC-3	<0.01	<2.4	753	<0.5	20.9	<1	979
17-Apr-03	14	Standard Deviation (mg/L)	0.0E+00	0.0E+00	1.0E+01	0.0E+00	9.2E+00	0.0E+00	2.6E+01
17-Apr-03	**14**	**Average Concentration (mg/L)**	**<0.01**	**<2.4**	**759.20**	**<0.5**	**15.56**	**<1**	**964.00**
25-Apr-03	22	ANAC-1	ND	<2.4	836	<0.5	<1.5	<1	1020
25-Apr-03	22	ANAC-2	ND	<2.4	818	<0.5	<1.5	<1	994
25-Apr-03	22	ANAC-3	ND	<2.4	825	<0.5	<1.5	<1	1016
25-Apr-03	22	Standard Deviation (mg/L)	0.0E+00	0.0E+00	9.1E+00	0.0E+00	0.0E+00	0.0E+00	1.4E+01
25-Apr-03	**22**	**Average Concentration (mg/L)**	**ND**	**<2.4**	**826.44**	**<0.5**	**<1.5**	**<1**	**1010.00**
01-May-03	28	ANAC-1	ND	<2.4	866	<0.5	<1.5	<1	917
01-May-03	28	ANAC-2	ND	<2.4	916	<0.5	<1.5	<1	1104
01-May-03	28	ANAC-3	ND	<2.4	884	<0.5	<1.5	<1	1078
01-May-03	28	Standard Deviation (mg/L)	0.0E+00	0.0E+00	2.5E+01	0.0E+00	0.0E+00	0.0E+00	1.0E+02
01-May-03	**28**	**Average Concentration (mg/L)**	**ND**	**<2.4**	**888.68**	**<0.5**	**<1.5**	**<1**	**1033.00**
14-May-03	41	ANAC-1	ND	<2.4	848	<0.5	<1.5	<1	1051
14-May-03	41	ANAC-2	ND	<2.4	817	<0.5	<1.5	<1	1015
14-May-03	41	ANAC-3	ND	<2.4	856	<0.5	<1.5	<1	1071
14-May-03	41	Standard Deviation (mg/L)	0.0E+00	0.0E+00	2.1E+01	0.0E+00	0.0E+00	0.0E+00	2.8E+01
14-May-03	**41**	**Average Concentration (mg/L)**	**ND**	**<2.4**	**840.33**	**<0.5**	**<1.5**	**<1**	**1045.67**
28-May-03	55	ANAC-1	ND	<2.4	878	<0.5	<1.5	<1	1219
28-May-03	55	ANAC-2	ND	<2.4	858	<0.5	<1.5	<1	1182
28-May-03	55	ANAC-3	ND	<2.4	861	<0.5	<1.5	<1	1199
28-May-03	55	Standard Deviation (mg/L)	0.0E+00	0.0E+00	1.0E+01	0.0E+00	0.0E+00	0.0E+00	1.9E+01
28-May-03	**55**	**Average Concentration (mg/L)**	**ND**	**<2.4**	**865.60**	**<0.5**	**<1.5**	**<1**	**1200.00**
16-Jun-03	74	ANAC-1	ND	<2.4	859	<0.5	<1.5	<1	1155
16-Jun-03	74	ANAC-2	ND	<2.4	838	<0.5	<1.5	<1	1148
16-Jun-03	74	ANAC-3	ND	<2.4	843	<0.5	<1.5	<1	1197
16-Jun-03	74	Standard Deviation (mg/L)	0.0E+00	0.0E+00	1.1E+01	0.0E+00	0.0E+00	0.0E+00	2.7E+01
16-Jun-03	**74**	**Average Concentration (mg/L)**	**ND**	**<2.4**	**846.51**	**<0.5**	**<1.5**	**<1**	**1166.67**

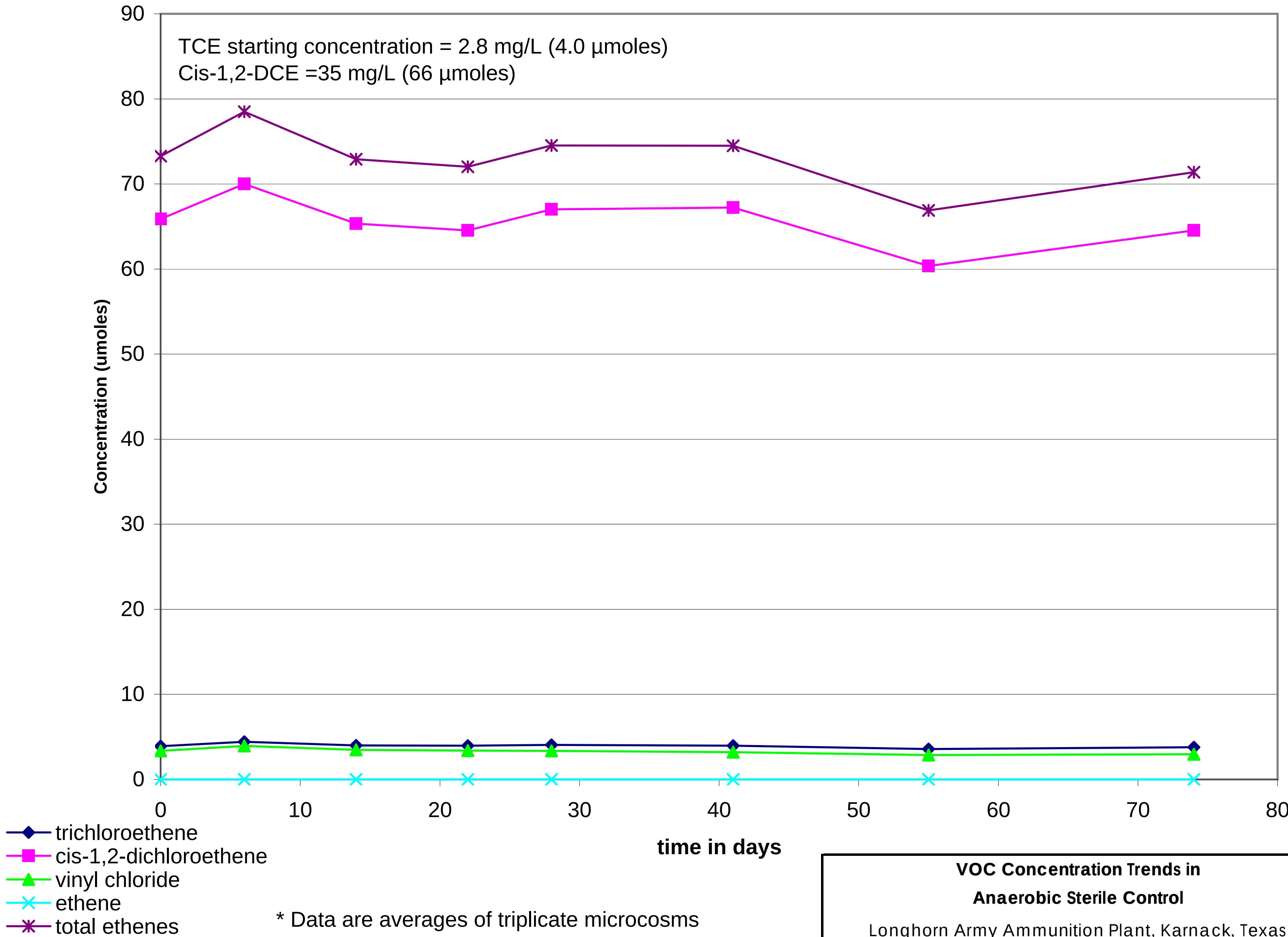
Table 2B: PERCHLORATE AND GEOCHEMICAL RAW DATA.
Longhorn Army Ammunition Plant, Karnack, Texas

Date	Day	Replicate	perchlorate mg/L	acetate & lactate* mg/L	chloride mg/L	nitrite mg/L	nitrate mg/L	phosphate mg/L	sulphate mg/L
Methanol, Ethanol, Acetate, Lactate									
03-Apr-03	0	MEAL-1	0.442	<2.4	792	<0.5	34.5	<1	958
03-Apr-03	0	MEAL-2	0.440	<2.4	797	<0.5	27.0	<1	968
03-Apr-03	0	MEAL-3	0.614	<2.4	828	<0.5	17.4	<1	1002
03-Apr-03	0	Standard Deviation (mg/L)	1.0E-01	0.0E+00	1.9E+01	0.0E+00	8.5E+00	0.0E+00	2.3E+01
03-Apr-03	**0**	**Average Concentration (mg/L)**	**0.50**	**<2.4**	**805.55**	**<0.5**	**26.29**	**<1**	**976.00**
09-Apr-03	6	MEAL-1	<0.01	258	812	<0.5	34.8	<1	1002
09-Apr-03	6	MEAL-2	0.346	241	834	<0.5	28.1	<1	1045
09-Apr-03	6	MEAL-3	<0.01	303	857	<0.5	25.6	<1	1052
09-Apr-03	6	Standard Deviation (mg/L)	2.0E-01	3.2E+01	2.2E+01	0.0E+00	4.8E+00	0.0E+00	2.7E+01
09-Apr-03	**6**	**Average Concentration (mg/L)**	**0.12**	**267.33**	**834.45**	**<0.5**	**29.51**	**<1**	**1033.00**
17-Apr-03	14	MEAL-1	<0.01	190	838	<0.5	9.7	<1	1100
17-Apr-03	14	MEAL-2	0.022	196	883	<0.5	17.0	<1	1135
17-Apr-03	14	MEAL-3	<0.01	272	846	<0.5	18.6	<1	1165
17-Apr-03	14	Standard Deviation (mg/L)	1.3E-02	4.6E+01	2.4E+01	0.0E+00	4.7E+00	0.0E+00	3.3E+01
17-Apr-03	**14**	**Average Concentration (mg/L)**	**0.01**	**219.33**	**855.71**	**<0.5**	**15.10**	**<1**	**1133.33**
25-Apr-03	22	MEAL-1	ND	180	823	<0.5	<1.5	<1	349
25-Apr-03	22	MEAL-2	<0.01	179	856	<0.5	<1.5	<1	554
25-Apr-03	22	MEAL-3	ND	290	821	<0.5	2.4	<1	713
25-Apr-03	22	Standard Deviation (mg/L)	0.0E+00	6.4E+01	1.9E+01	0.0E+00	1.4E+00	0.0E+00	1.8E+02
25-Apr-03	**22**	**Average Concentration (mg/L)**	**ND**	**216.47**	**833.19**	**<0.5**	**0.81**	**<1**	**538.67**
01-May-03	28	MEAL-1	ND	267	969	<0.5	<1.5	<1	15
01-May-03	28	MEAL-2	ND	208	802	<0.5	<1.5	<1	46
01-May-03	28	MEAL-3	ND	189	721	<0.5	<1.5	<1	306
01-May-03	28	Standard Deviation (mg/L)	0.0E+00	4.1E+01	1.3E+02	0.0E+00	0.0E+00	0.0E+00	1.6E+02
01-May-03	**28**	**Average Concentration (mg/L)**	**ND**	**221.21**	**830.70**	**0.50**	**0.00**	**<1**	**122.33**
14-May-03	41	MEAL-1	ND	214	1019	<0.5	<1.5	<1	14
14-May-03	41	MEAL-2	ND	182	853	<0.5	<1.5	<1	54
14-May-03	41	MEAL-3	ND	80	859	<0.5	<1.5	<1	16
14-May-03	41	Standard Deviation (mg/L)	0.0E+00	7.0E+01	9.4E+01	0.0E+00	0.0E+00	0.0E+00	2.3E+01
14-May-03	**41**	**Average Concentration (mg/L)**	**ND**	**158.67**	**910.33**	**<0.5**	**0.00**	**<1**	**28.00**
28-May-03	55	MEAL-1	ND	202	861	<0.5	<1.5	<1	<0.5
28-May-03	55	MEAL-2	ND	231	868	<0.5	<1.5	<1	<0.5
28-May-03	55	MEAL-3	ND	143	843	<0.5	<1.5	<1	<0.5
28-May-03	55	Standard Deviation (mg/L)	0.0E+00	4.4E+01	1.3E+01	0.0E+00	0.0E+00	0.0E+00	0.0E+00
28-May-03	**55**	**Average Concentration (mg/L)**	**ND**	**191.89**	**857.21**	**<0.5**	**<1.5**	**<1**	**<0.5**
16-Jun-03	74	MEAL-1	ND	184	839	<0.5	<1.5	<1	<0.5
16-Jun-03	74	MEAL-2	ND	293	824	<0.5	<1.5	<1	<0.5
16-Jun-03	74	MEAL-3	ND	210	870	<0.5	<1.5	<1	<0.5
16-Jun-03	74	Standard Deviation (mg/L)	0.0E+00	5.7E+01	2.3E+01	0.0E+00	0.0E+00	0.0E+00	0.0E+00
16-Jun-03	**74**	**Average Concentration (mg/L)**	**ND**	**228.98**	**844.69**	**<0.5**	**<1.5**	**<1**	**<0.5**

Table 2B: PERCHLORATE AND GEOCHEMICAL RAW DATA
Longhorn Army Ammunition Plant, Karnack, Texas

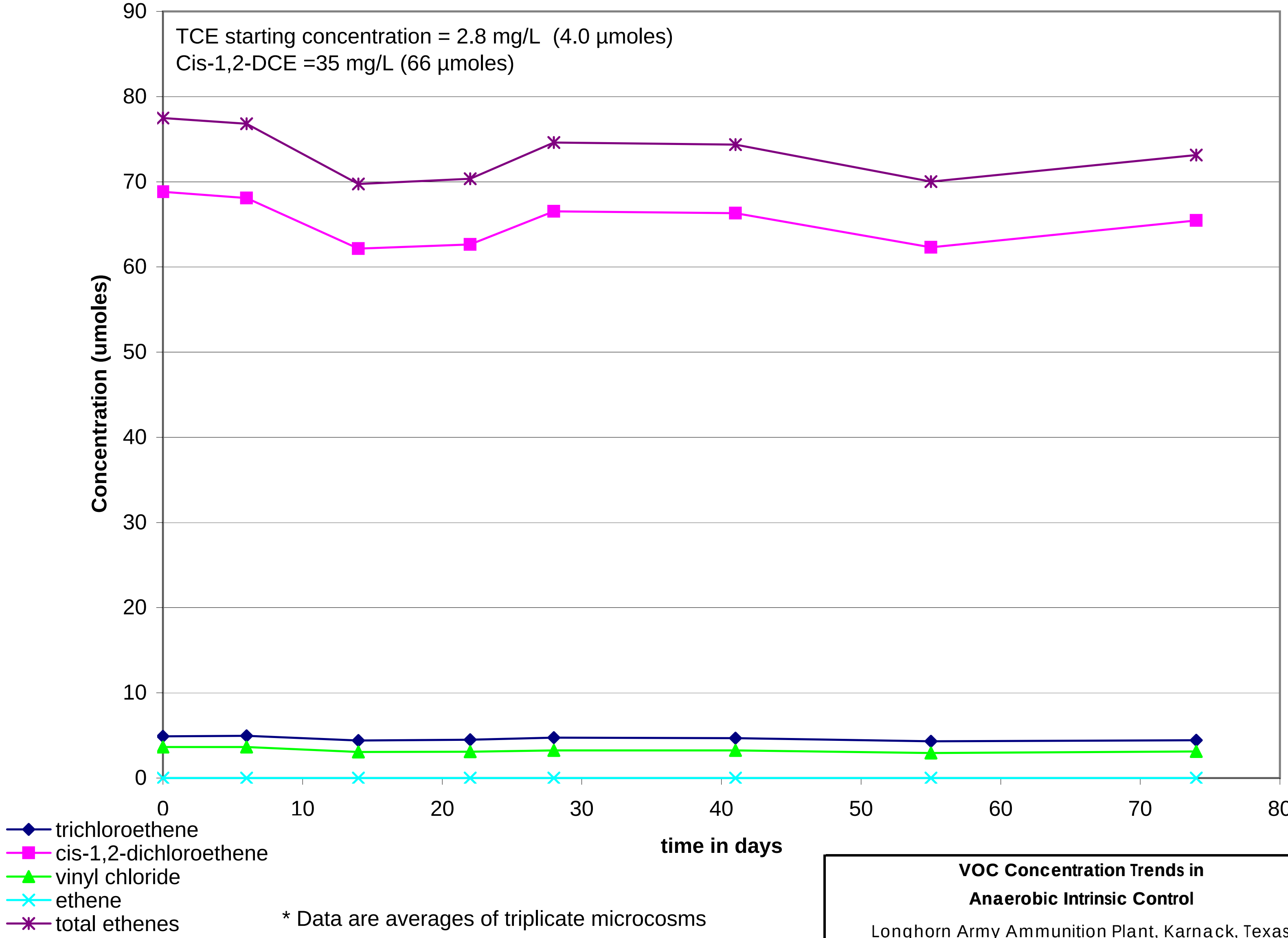
Date	Day	Replicate	perchlorate mg/L	acetate & lactate* mg/L	chloride mg/L	nitrite mg/L	nitrate mg/L	phosphate mg/L	sulphate mg/L
Methanol, Ethanol, Acetate, Lactate and KB 1									
03-Apr-03	0	MEA+KB 1-1	0.573	<2.4	813	<0.5	23.3	<1	996
03-Apr-03	0	MEA+KB 1-2	0.452	<2.4	584	<0.5	26.0	<1	815
03-Apr-03	0	MEA+KB 1-3	0.503	<2.4	814	<0.5	30.1	<1	995
03-Apr-03	0	Standard Deviation (mg/L)	6.1E-02	0.0E+00	1.3E+02	0.0E+00	3.4E+00	0.0E+00	1.0E+02
03-Apr-03	**0**	**Average Concentration (mg/L)**	**0.51**	**<2.4**	**737.00**	**<0.5**	**26.47**	**<1**	**935.33**
09-Apr-03	6	MEA+KB 1-1	<0.01	250	858	<0.5	22.0	<1	1060
09-Apr-03	6	MEA+KB 1-2	<0.01	347	882	<0.5	13.3	<1	1085
09-Apr-03	6	MEA+KB 1-3	<0.01	252	859	<0.5	21.6	<1	1078
09-Apr-03	6	Standard Deviation (mg/L)	0.0E+00	5.5E+01	1.3E+01	0.0E+00	4.9E+00	0.0E+00	1.3E+01
09-Apr-03	**6**	**Average Concentration (mg/L)**	**<0.01**	**283.00**	**866.35**	**<0.5**	**18.97**	**<1**	**1074.33**
17-Apr-03	14	MEA+KB 1-1	<0.01	278	861	<0.5	18.6	<1	1088
17-Apr-03	14	MEA+KB 1-2	<0.01	215	795	<0.5	3.3	<1	1034
17-Apr-03	14	MEA+KB 1-3	<0.01	222	872	<0.5	14.9	<1	1141
17-Apr-03	14	Standard Deviation (mg/L)	0.0E+00	3.5E+01	4.1E+01	0.0E+00	8.0E+00	0.0E+00	5.4E+01
17-Apr-03	**14**	**Average Concentration (mg/L)**	**<0.01**	**238.33**	**842.79**	**<0.5**	**12.28**	**<1**	**1087.67**
25-Apr-03	22	MEA+KB 1-1	ND	276	825	<0.5	<1.5	<1	661
25-Apr-03	22	MEA+KB 1-2	ND	133	838	<0.5	<1.5	<1	344
25-Apr-03	22	MEA+KB 1-3	ND	167	820	<0.5	<1.5	<1	499
25-Apr-03	22	Standard Deviation (mg/L)	0.0E+00	7.5E+01	9.6E+00	0.0E+00	0.0E+00	0.0E+00	1.6E+02
25-Apr-03	**22**	**Average Concentration (mg/L)**	**ND**	**191.75**	**827.51**	**<0.5**	**<1.5**	**<1**	**501.33**
01-May-03	28	MEA+KB 1-1	ND	218	888	<0.5	<1.5	<1	103
01-May-03	28	MEA+KB 1-2	ND	169	912	<0.5	<1.5	<1	44
01-May-03	28	MEA+KB 1-3	ND	141	834	<0.5	<1.5	<1	37
01-May-03	28	Standard Deviation (mg/L)	0.0E+00	3.9E+01	4.0E+01	0.0E+00	0.0E+00	0.0E+00	3.6E+01
01-May-03	**28**	**Average Concentration (mg/L)**	**ND**	**175.98**	**878.03**	**<0.5**	**<1.5**	**<1**	**61.33**
14-May-03	41	MEA+KB 1-1	ND	189	863	<0.5	<1.5	<1	11
14-May-03	41	MEA+KB 1-2	ND	227	849	<0.5	<1.5	<1	2
14-May-03	41	MEA+KB 1-3	ND	219	873	<0.5	<1.5	<1	40
14-May-03	41	Standard Deviation (mg/L)	0.0E+00	2.0E+01	1.2E+01	0.0E+00	0.0E+00	0.0E+00	2.0E+01
14-May-03	**41**	**Average Concentration (mg/L)**	**ND**	**211.67**	**861.67**	**<0.5**	**<1.5**	**<1**	**17.67**
28-May-03	55	MEA+KB 1-1	ND	179	886	<0.5	<1.5	<1	<0.5
28-May-03	55	MEA+KB 1-2	ND	277	878	<0.5	<1.5	<1	<0.5
28-May-03	55	MEA+KB 1-3	ND	218	949	<0.5	<1.5	<1	<0.5
28-May-03	55	Standard Deviation (mg/L)	0.0E+00	4.9E+01	3.9E+01	0.0E+00	0.0E+00	0.0E+00	0.0E+00
28-May-03	**55**	**Average Concentration (mg/L)**	**ND**	**224.55**	**904.42**	**<0.5**	**<1.5**	**<1**	**0.00**
16-Jun-03	74	MEA+KB 1-1	ND	210	901	<0.5	<1.5	<1	<0.5
16-Jun-03	74	MEA+KB 1-2	ND	248	895	<0.5	<1.5	<1	<0.5
16-Jun-03	74	MEA+KB 1-3	ND	200	903	<0.5	<1.5	<1	<0.5
16-Jun-03	74	Standard Deviation (mg/L)	0.0E+00	2.5E+01	4.2E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
16-Jun-03	**74**	**Average Concentration (mg/L)**	**ND**	**219.42**	**899.65**	**<0.5**	**<1.5**	**<1**	**0.00**

Notes: ND = not determined, analysis not conducted



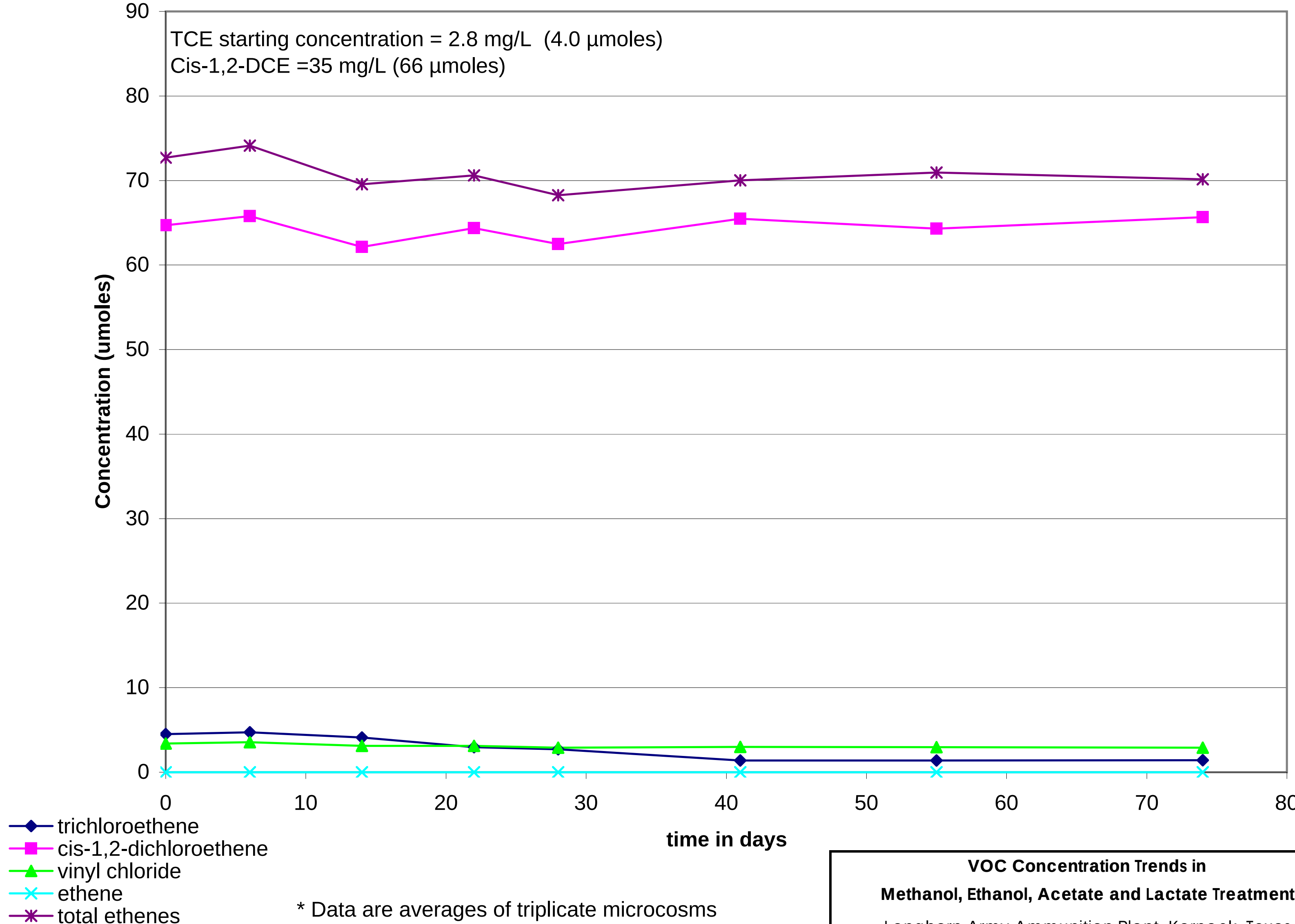
* Data are averages of triplicate microcosms

VOC Concentration Trends in Anaerobic Sterile Control Longhorn Army Ammunition Plant, Karnack, Texas		
Sept. 2003	Figure: **1**	SiREM Site Recovery & Management

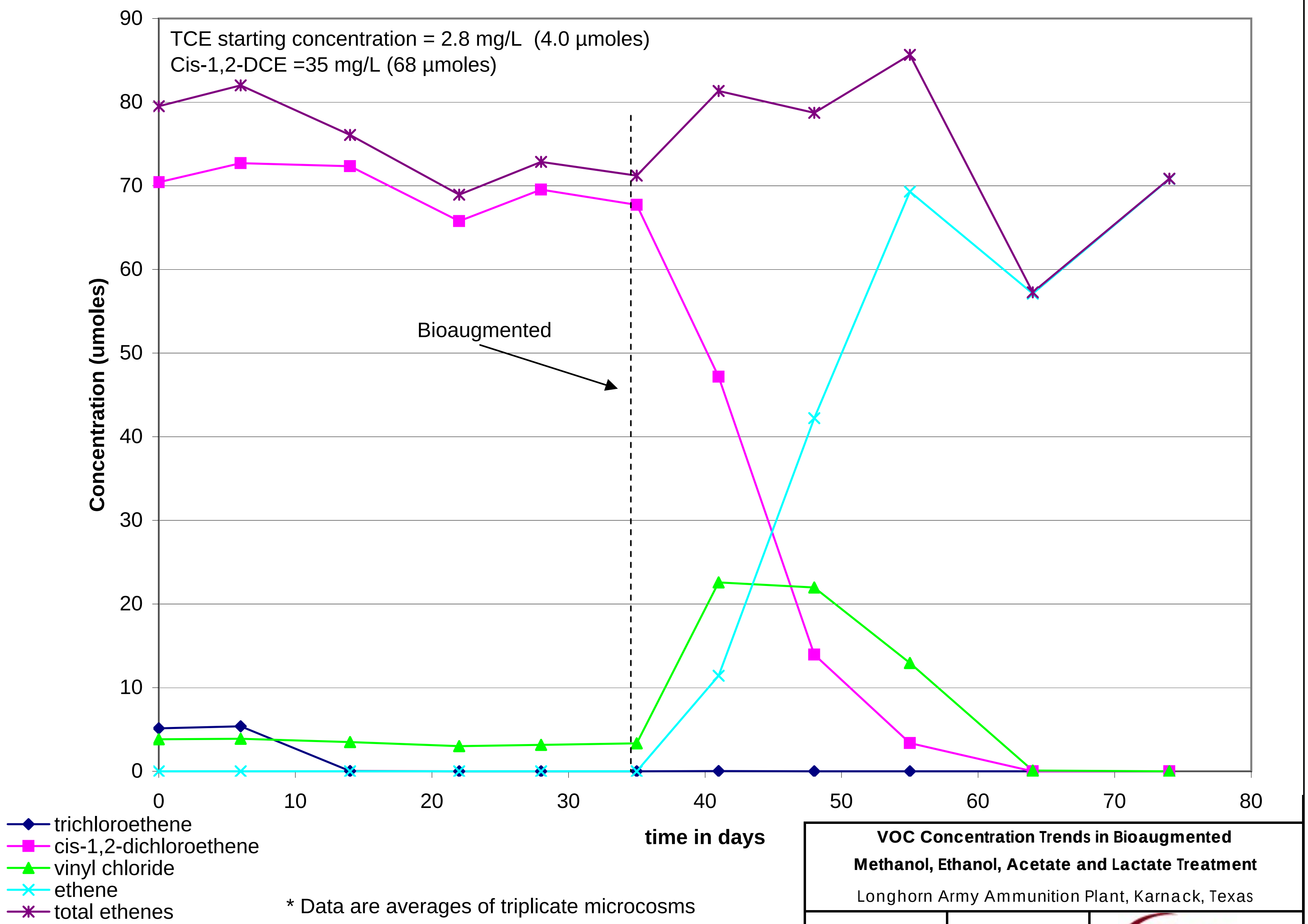


* Data are averages of triplicate microcosms

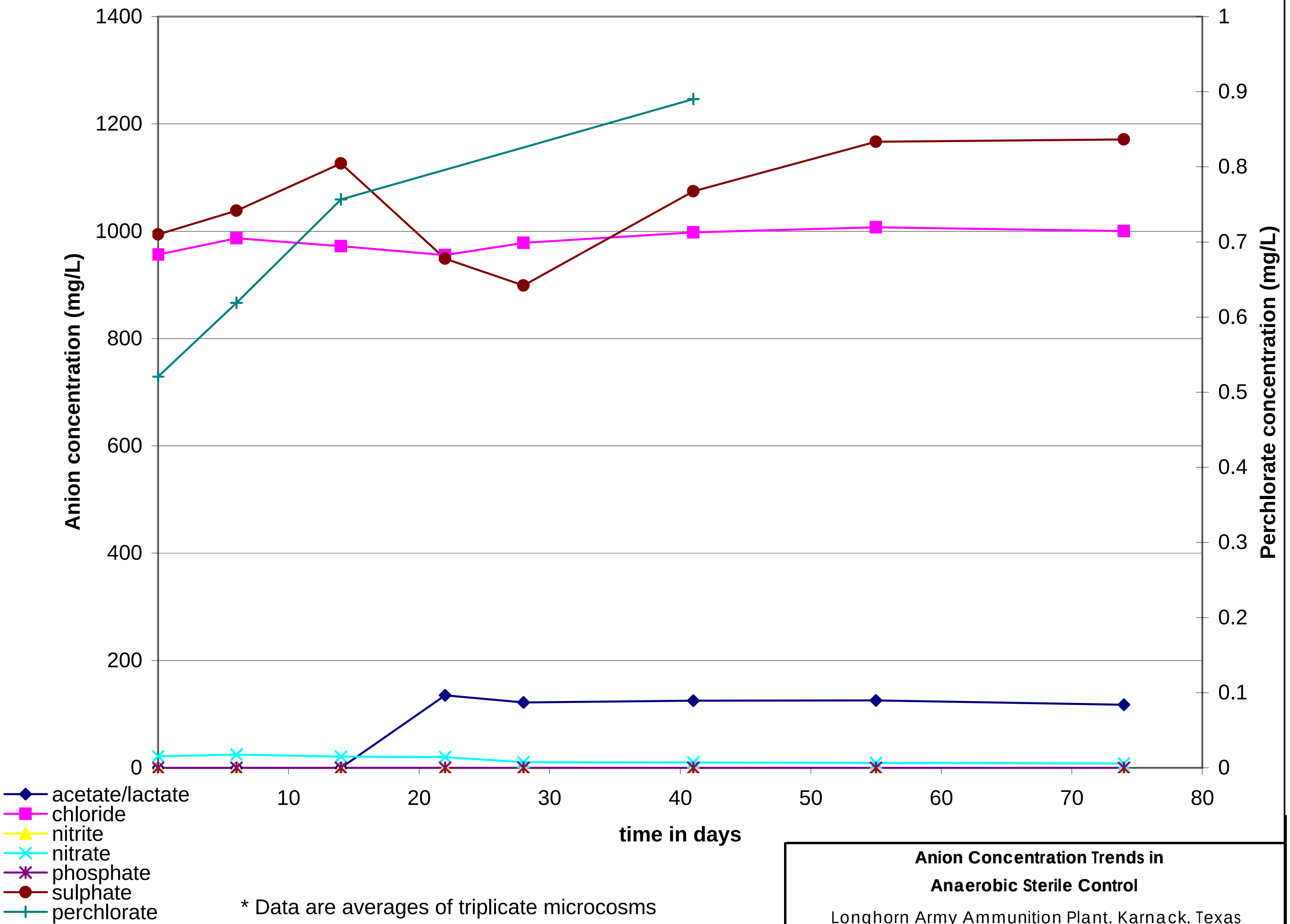
VOC Concentration Trends in Anaerobic Intrinsic Control Longhorn Army Ammunition Plant, Karnack, Texas		
Sept. 2003	Figure: **2**	SiREM Site Recovery & Management



VOC Concentration Trends in **Methanol, Ethanol, Acetate and Lactate Treatment** Longhorn Army Ammunition Plant, Karnack, Texas		
Sept. 2003	Figure: **3**	SiREM Site Recovery & Management



VOC Concentration Trends in Bioaugmented Methanol, Ethanol, Acetate and Lactate Treatment Longhorn Army Ammunition Plant, Karnack, Texas		
Sept. 2003	Figure: **4**	SiREM Site Recovery & Management

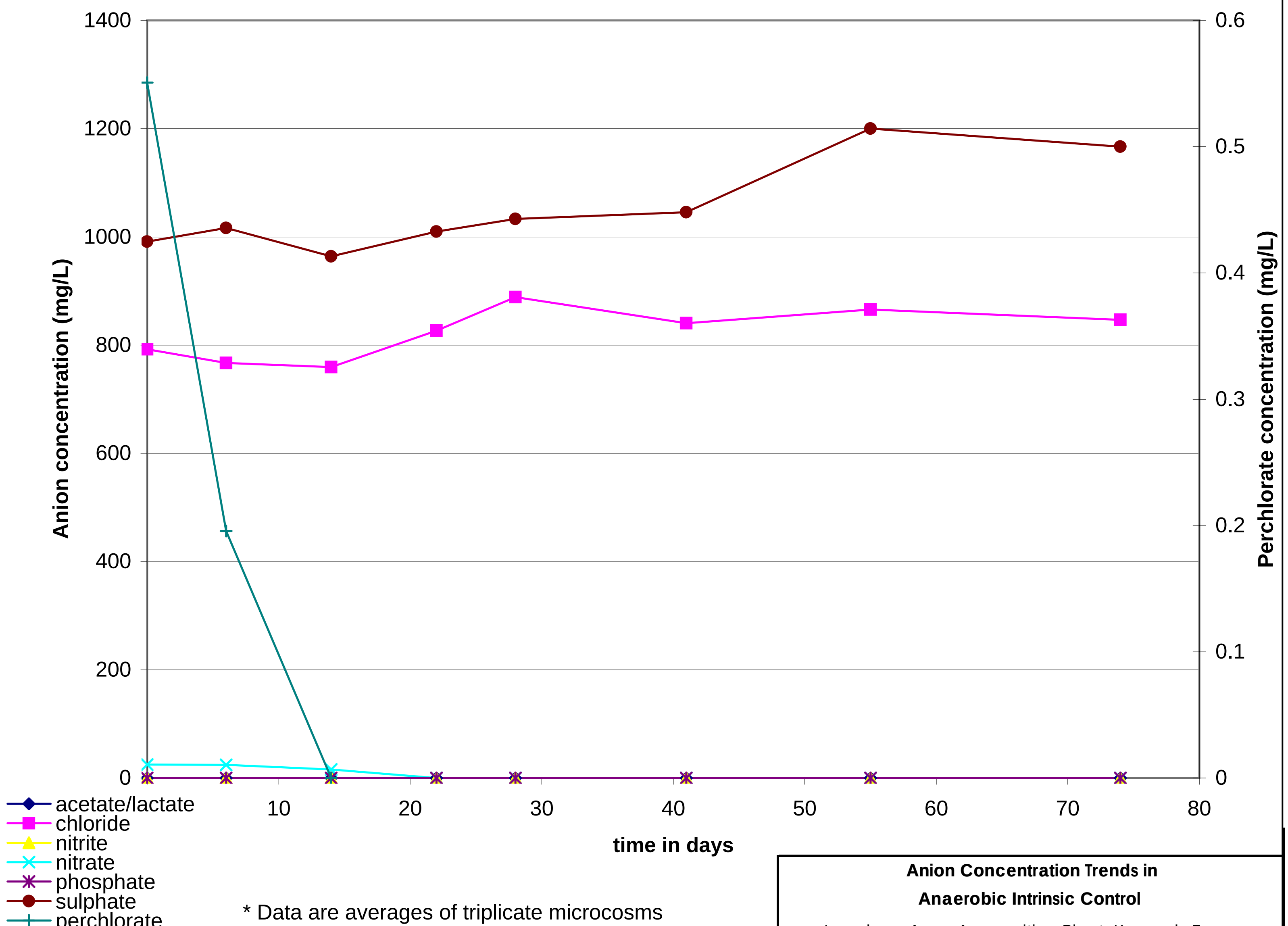


Anion Concentration Trends in

Anaerobic Sterile Control

Longhorn Army Ammunition Plant, Karnack, Texas

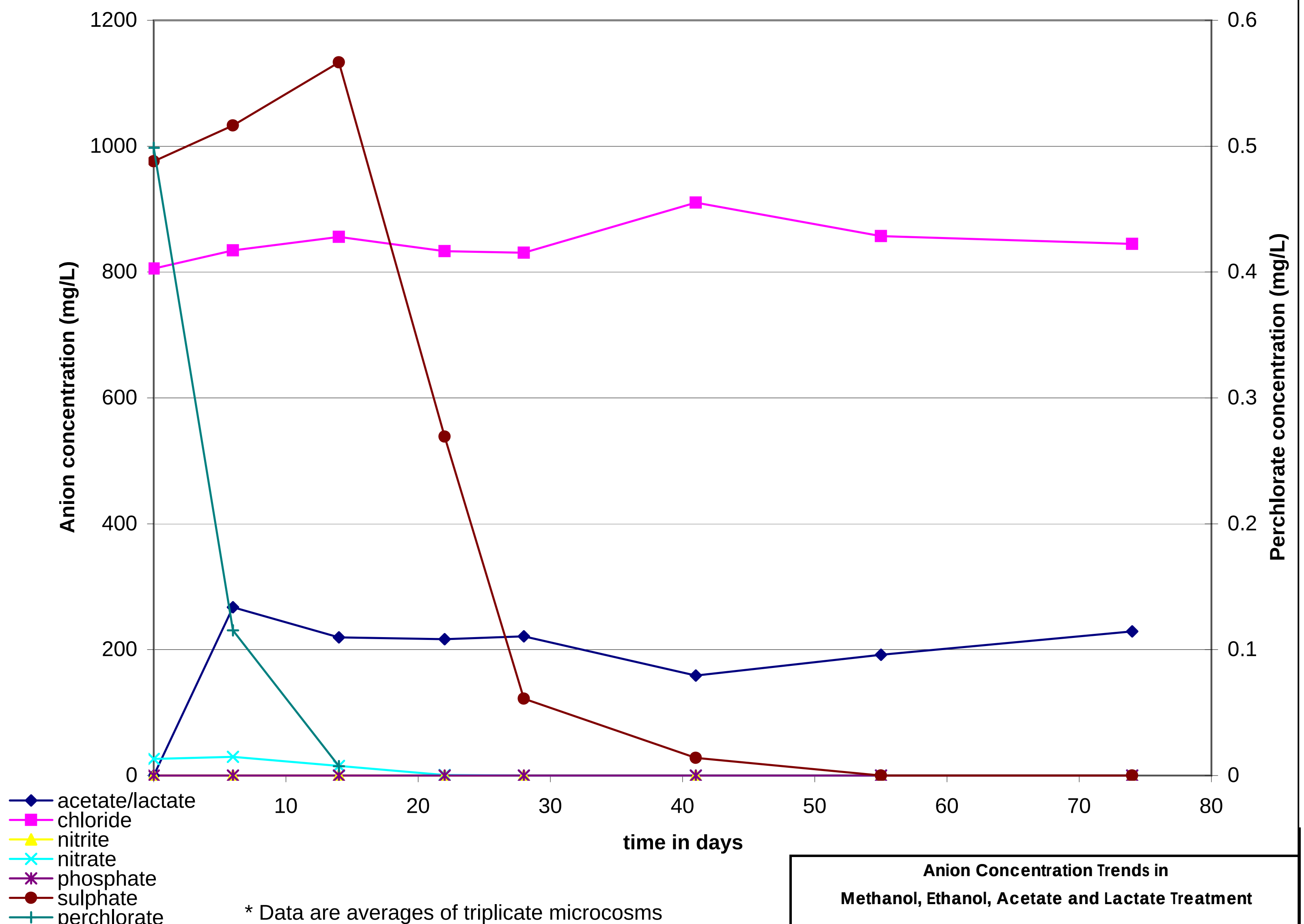
Sept.2003	Figure: **5**	SiREM Site Recovery & Management



* Data are averages of triplicate microcosms

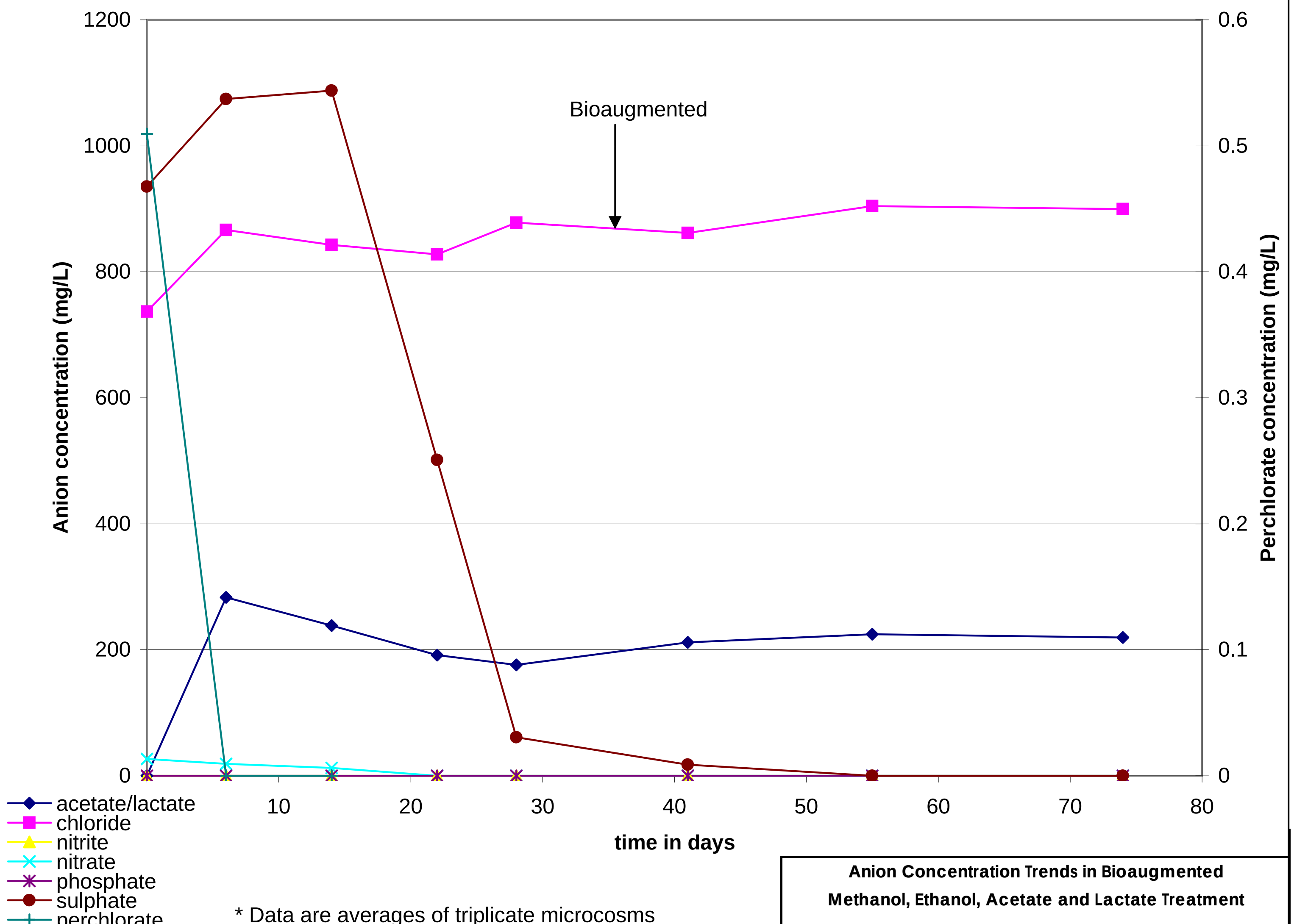
Anion Concentration Trends in
Anaerobic Intrinsic Control
Longhorn Army Ammunition Plant, Karnack, Texas

Sept. 2003	Figure: **6**	SiREM Site Recovery & Management



* Data are averages of triplicate microcosms

Anion Concentration Trends in Methanol, Ethanol, Acetate and Lactate Treatment Longhorn Army Ammunition Plant, Karnack, Texas		
Sept. 2003	Figure: **7**	SiREM Site Recovery & Management



* Data are averages of triplicate microcosms

Anion Concentration Trends in Bioaugmented Methanol, Ethanol, Acetate and Lactate Treatment

Longhorn Army Ammunition Plant, Karnack, Texas

Sept. 2003	Figure: **8**	SiREM

APPENDIX A

BIOTREATABILITY LABORATORY ANALYTICAL METHODS

VOCS, Dissolved Hydrocarbon Gases, Methanol and Ethanol Analysis

This section describes the methods to quantify the chlorinated ethenes as well as methane, ethene, methanol and ethanol. The practical quantitation limit (PQL) for the chlorinated ethenes (PCE, TCE, cis-DCE and vinyl chloride) and ethene was 10 µg/L. The PQL for methanol and ethanol was 1 mg/L.

VOC concentrations were measured using a Hewlett-Packard (HP5890 series II) gas chromatograph (GC) equipped with a head-space autosampler (Hewlett Packard 7684) programmed to heat each sample to 75 ^{o}C for 40 minutes prior to injection into a SUPEL-Q™ Plot column (0.53 mm x 30 m, Supelco) and a flame ionization detector (FID). The injector temperature was 200^{o}C, and the detector temperature was 250^{o}C. The oven temperature was programmed as follows: 35^{o}C for 2 minutes, increase to 100^{o}C at 10^{o}C/min, then increase to 185°C at 6°C/min and hold at 185 ^{o}C for 1.34 minutes. The carrier gas was helium at a flow rate of 11 mL/min.

VOC concentrations in the liquid phase of the microcosms were measured by withdrawing 1 mL of liquid from each microcosm and injecting the sample into a 10-mL headspace vial containing 5 mL of acidified deionized water. The vial was sealed with an inert Teflon-coated septum and aluminum crimp cap for automated injection onto the CG. A three-point calibration was performed using methanolic stock solutions containing known concentrations of the target analytes. Calibration was performed using external standards that were prepared gravimetrically, or were purchased as standard solutions. The data from the GCs were integrated using HPChem software (Hewlett Packard). Data can be reviewed and re-integrated at a later date, but the raw data cannot be modified.

Anions, Lactate, Acetate and Perchlorate Analysis

This section describes the methods to quantify anions, lactate, acetate and perchlorate. The PQL for the standard anions was 0.71 mg/L chloride, 0.28

4. CONCLUSIONS

Based on the results of this biotreatability study the following conclusions can be provided:

1. Complete degradation of perchlorate was observed in absence of added electron donor within 15 days of initiation of the test. Addition of soluble electron donor resulted in rapid degradation of perchlorate within 5 to 15 days.

2. The site groundwater and soil does not contain adequate naturally containing electron donors to promote rapid reductive dechlorination of TCE

3. The addition of soluble electron donor (MEAL) did not result in any cis-DCE dechlorination over the incubation period. This suggests that these electron donors alone may not be suitable to promote any indigenous *Dehalococcoides* that may be present at the site or a greater acclimation period is needed.

4. Complete and rapid dechlorination of TCE and cis-DCE via vinyl chloride to ethene was also observed in the bioaugmented microcosm amended with soluble electron donor (MEAL) and the natural, non-pathogenic microbial consortium KB-1.

APPENDIX C

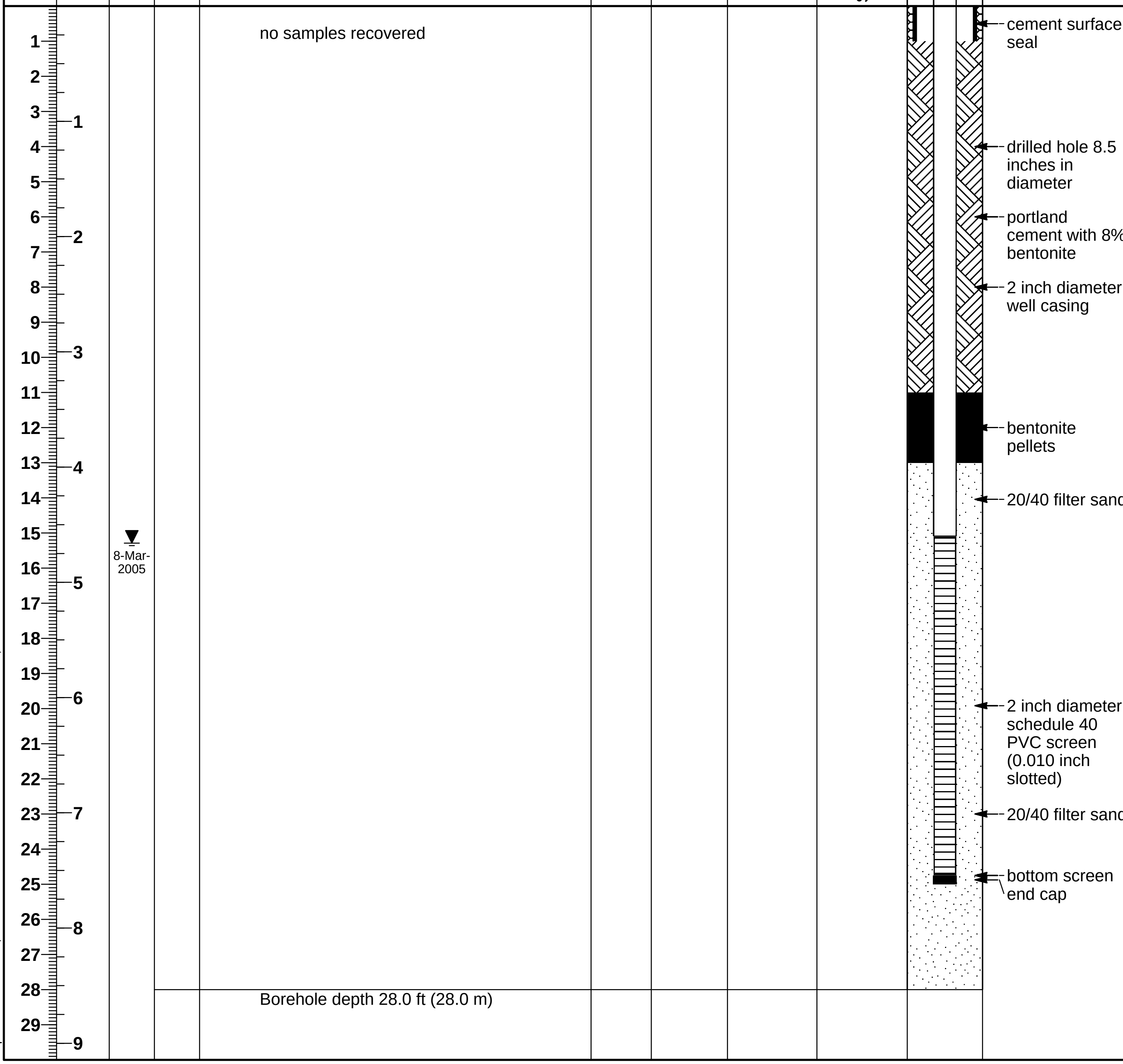
BOREHOLE LOGS & WELL CONSTRUCTION DETAILS

Borehole No. 16PM01

Borehole Log

Project No.:	TR0136	**Location:**	Site 16 Landfill
Client:	Longhorn Army Ammunition Plant	**Coordinates:**	N 6,953,672.6 E 3,313,969.2
Geologist:	N. Barros	**Drilling Method:**	Hollow Stem Augers
		Well Material:	4 inch PVC Vee-Wire Wrap
Drilling Company:	ETTL Drilling Services	**Borehole Diameter:**	8.5 inches
Completion Date:	24 June 2003	**Site Datum:**	Site 16 Landfill Benchmark

Depth, feet	Depth, metres	Water Level	Stratigraphy	Lithologic Description	Unified Soil Classification	Recovery, %	PID (ppmv)	Soil Sample ID	Well Configuration	Elevations (ft amsl) and Comments
										Ground Surface 187.5
										Top PVC Casing 190.5
0–28		15 ft (8-Mar-2005)		no samples recovered						cement surface seal; drilled hole 8.5 inches in diameter; portland cement with 8% bentonite; 2 inch diameter well casing; bentonite pellets; 20/40 filter sand; 2 inch diameter schedule 40 PVC screen (0.010 inch slotted); 20/40 filter sand; bottom screen end cap
28				Borehole depth 28.0 ft (28.0 m)						

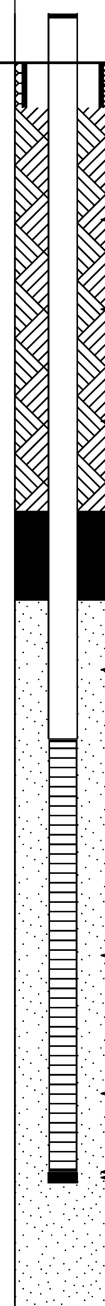


GEOSYNTEC CONSULTANTS

Borehole No. 16PM02

Borehole Log

Project No.:	TR0136	**Location:**	Site 16 Landfill
Client:	Longhorn Army Ammunition Plant	**Coordinates:**	N 6,953,637.4 E 3,313,977.1
Geologist:	N. Barros	**Drilling Method:**	Hollow Stem Augers
		Well Material:	4 inch PVC Vee-Wire Wrap
Drilling Company:	ETTL Drilling Services	**Borehole Diameter:**	8.5 inches
Completion Date:	24 June 2003	**Site Datum:**	Site 16 Landfill Benchmark

Depth, feet	Depth, metres	Water Level	Stratigraphy	Lithologic Description	Unified Soil Classification	Recovery, %	PID (ppmv)	Soil Sample ID	Well Configuration	Elevations (ft amsl) and Comments
										Ground Surface 188.0
										Top PVC Casing 191.1
0–28	0–8.5	8-Mar-2005 (approx. 15.7 ft)		no samples recovered						cement surface seal; drilled hole 8.5 inches in diameter; portland cement with 8% bentonite; 2 inch diameter well casing; bentonite pellets; 20/40 filter sand; 2 inch diameter schedule 40 PVC screen (0.010 inch slotted); 20/40 filter sand; bottom screen end cap
28				Borehole depth 28.0 ft (28.0 m)						

Depth scale, feet: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29

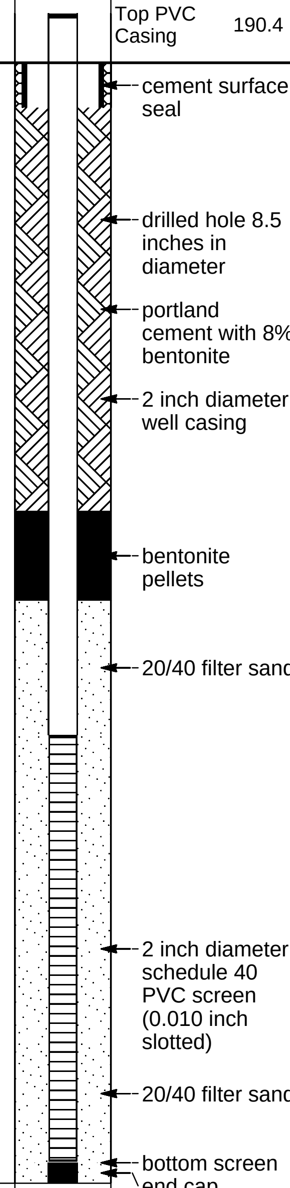
Depth scale, metres: 1 2 3 4 5 6 7 8 9

Borehole No. 16PM03

Borehole Log

Project No.:	TR0136	**Location:**	Site 16 Landfill
Client:	Longhorn Army Ammunition Plant	**Coordinates:**	N 6,953,706.8 E 3,313,985.1
Geologist:	D. Bertrand	**Drilling Method:**	Hollow Stem Augers
Drilling Company:	ETTL Drilling Services	**Well Material:**	4 inch PVC Vee-Wire Wrap
Completion Date:	25 June 2003	**Borehole Diameter:**	8.5 inches
		Site Datum:	Site 16 Landfill Benchmark

Depth, feet	Depth, metres	Water Level	Stratigraphy	Lithologic Description	Unified Soil Classification	Recovery, %	PID (ppmv)	Soil Sample ID	Well Configuration	Elevations (ft amsl) and Comments
										Ground Surface 187.5
										Top PVC Casing 190.4
0–25	0–7.6	15.4 ft (8-Mar-2005)		no samples recovered						
25				Borehole depth 25.0 ft (25.0 m)						



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Borehole No. 16PM04

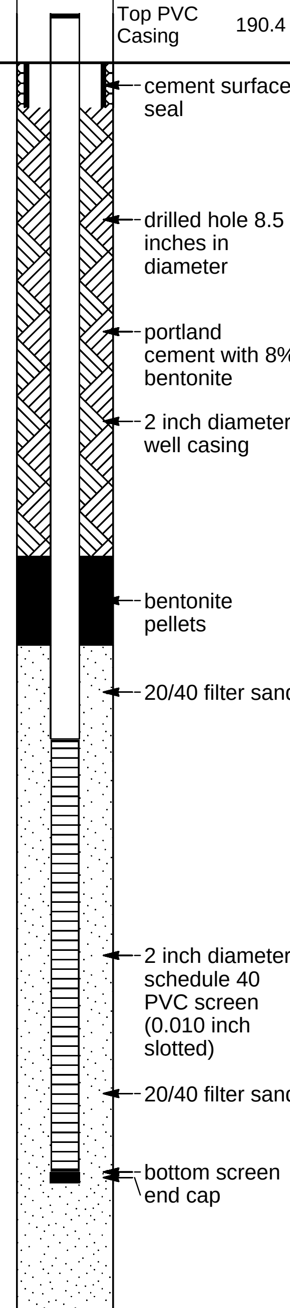
Borehole Log

Project No.:	TR0136	**Location:**	Site 16 Landfill
Client:	Longhorn Army Ammunition Plant	**Coordinates:**	N 6,953,687.7 E 3,314,002.8
Geologist:	N. Barros	**Drilling Method:**	Hollow Stem Augers
		Well Material:	4 inch PVC Vee-Wire Wrap
Drilling Company:	ETTL Drilling Services	**Borehole Diameter:**	8.5 inches
Completion Date:	23 June 2003	**Site Datum:**	Site 16 Landfill Benchmark

Depth, feet	Depth, metres	Water Level	Stratigraphy	Lithologic Description	Unified Soil Classification	Recovery, %	PID (ppmv)	Soil Sample ID	Well Configuration	Elevations (ft amsl) and Comments
										Ground Surface 187.0
										Top PVC Casing 190.4
0	0			no samples recovered						
15		8-Mar-2005								
28				Borehole depth 28.0 ft (28.0 m)						

Depth, feet: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29

Depth, metres: 1, 2, 3, 4, 5, 6, 7, 8, 9



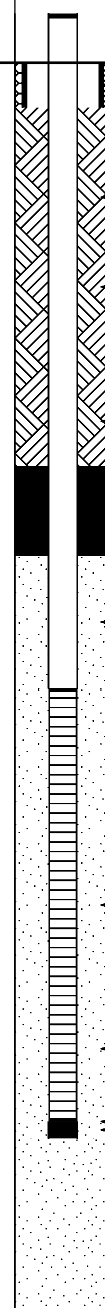
GEOSYNTEC CONSULTANTS

Borehole No. 16PM05

Borehole Log

Project No.:	TR0136	**Location:**	Site 16 Landfill
Client:	Longhorn Army Ammunition Plant	**Coordinates:**	N 6,953,609.9 E 3,314,000.7
Geologist:	D. Bertrand	**Drilling Method:**	Hollow Stem Augers
Drilling Company:	ETTL Drilling Services	**Well Material:**	4 inch PVC Vee-Wire Wrap
Completion Date:	23 June 2003	**Borehole Diameter:**	8.5 inches
		Site Datum:	Site 16 Landfill Benchmark

Depth, feet	Depth, metres	Water Level	Stratigraphy	Lithologic Description	Unified Soil Classification	Recovery, %	PID (ppmv)	Soil Sample ID	Well Configuration	Elevations (ft amsl) and Comments
										Ground Surface 185.9
										Top PVC Casing 189.0
0–28	0–8.5	8-Mar-2005 (at ~13.5 ft)		no samples recovered						cement surface seal; drilled hole 8.5 inches in diameter; portland cement with 8% bentonite; 2 inch diameter well casing; bentonite pellets; 20/40 filter sand; 2 inch diameter schedule 40 PVC screen (0.010 inch slotted); 20/40 filter sand; bottom screen end cap
28				Borehole depth 28.0 ft (28.0 m)						

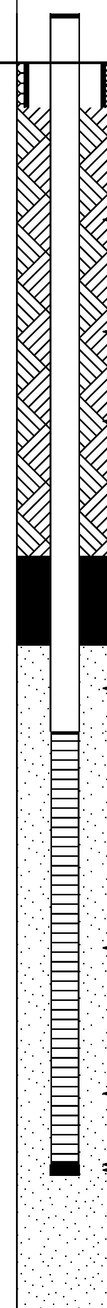


Borehole No. 16PM06

Borehole Log

Project No.:	TR0136	**Location:**	Site 16 Landfill
Client:	Longhorn Army Ammunition Plant	**Coordinates:**	N 6,953,668.3 E 3,314,010.1
Geologist:	N. Barros	**Drilling Method:**	Hollow Stem Augers
		Well Material:	4 inch PVC Vee-Wire Wrap
Drilling Company:	ETTL Drilling Services	**Borehole Diameter:**	8.5 inches
Completion Date:	24 June 2003	**Site Datum:**	Site 16 Landfill Benchmark

Depth, feet	Depth, metres	Water Level	Stratigraphy	Lithologic Description	Unified Soil Classification	Recovery, %	PID (ppmv)	Soil Sample ID	Well Configuration	Elevations (ft amsl) and Comments
0				no samples recovered						Ground Surface 186.4; Top PVC Casing 189.6
1										cement surface seal
3.5	1									drilled hole 8.5 inches in diameter
6	2									portland cement with 8% bentonite
8										2 inch diameter well casing
10	3									
12										bentonite pellets
13	4									
14		8-Mar-2005								20/40 filter sand
16.5	5									
20	6									2 inch diameter schedule 40 PVC screen (0.010 inch slotted)
23	7									20/40 filter sand
24.5										bottom screen end cap
26	8									
28				Borehole depth 28.0 ft (28.0 m)						
29.5	9									



Borehole No. 16PM07D

Borehole Log

Project No.:	TR0136	**Location:**	Site 16 Landfill
Client:	Longhorn Army Ammunition Plant	**Coordinates:**	N 6,953,683.1 E 3,314,012.4
Geologist:	N. Barros	**Drilling Method:**	Hollow Stem Augers
Drilling Company:	ETTL Drilling Services	**Well Material:**	4 inch PVC Vee-Wire Wrap
Completion Date:	23 June 2003	**Borehole Diameter:**	8.5 inches
		Site Datum:	Site 16 Landfill Benchmark

Elevations (ft amsl) and Comments: Ground Surface 187.2; Top PVC Casing 190.4

Depth, feet	Depth, metres	Water Level	Stratigraphy	Lithologic Description	Unified Soil Classification	Recovery, %	PID (ppmv)	Soil Sample ID	Well Configuration / Comments
0–3				no samples recovered					cement surface seal
3–9	1–2			silt, some clay, trace sand, fine, stiff, mottled red-brown and grey, dry to moist; mottled brown and black	MLCS	93	NA	SS-1	drilled hole 8.5 inches in diameter; portland cement with 8% bentonite; 1 inch diameter well casing
9–9.5				silty sand, fine to medium, loose, mottled brown grey, dry to moist	SM	100	NA	SS-2	
9.5–12.5	3			clayey sand, fine to medium, stiff, mottled brown and grey, moist; clay lenses	SC				bentonite pellets; 20/40 filter sand
12.5–14	4			silty sand, trace clay, fine to medium, loose, grey, moist to wet; medium to coarse, very loose, brown grey, very wet	SM				20/40 filter sand

Borehole No. 16PM07D

Borehole Log

Project No.: TR0136
Client: Longhorn Army Ammunition Plant
Geologist: N. Barros
Drilling Company: ETTL Drilling Services
Completion Date: 23 June 2003

Location: Site 16 Landfill
Coordinates: N 6,953,683.1 E 3,314,012.4
Drilling Method: Hollow Stem Augers
Well Material: 4 inch PVC Vee-Wire Wrap
Borehole Diameter: 8.5 inches
Site Datum: Site 16 Landfill Benchmark

Depth, feet	Depth, metres	Water Level	Stratigraphy	Lithologic Description	Unified Soil Classification	Recovery, %	PID (ppmv)	Soil Sample ID	Well Configuration	Elevations (ft amsl) and Comments
										Ground Surface 187.2
										Top PVC Casing 190.4
15		8-Mar-2005		clay lens (15' - 15'2")	SM	78	NA	SS-3		16PM07-S: 1 inch diameter schedule 40 PVC screen (0.010 inch slotted)
				sandy clay, fine to medium, very stiff, brown and grey, moist to wet	CLS					
16	5			silty clay, fine, very stiff, mottled grey and brown, moist	CLM					
17										bottom of screen end cap 20/40 filter sand
18				sandy clay, some silt, medium, loose, brown and grey, moist to wet	CLMS	97	NA	SS-4		bentonite pellets
19	6			clay, trace silt, fine, very stiff, mottled grey and brown, moist	CL					
20–21										20/40 filter sand
22				sandy clay						
	7			silty sand, some clay, medium to coarse, loose, grey, wet brown, clay lenses	SM CLS					
23						92	NA	SS-5		20/40 filter sand
24–25										16PM07-D: 1 inch diameter schedule 40 PVC screen (0.010 inch slotted)
26	8									bottom of screen end cap
27				clayey sand, some silt, medium, loose, mottled brown and grey, moist	SC SM					
28				Borehole depth 28.0 ft (28.0 m)						

Borehole No. 16PM07S

Borehole Log

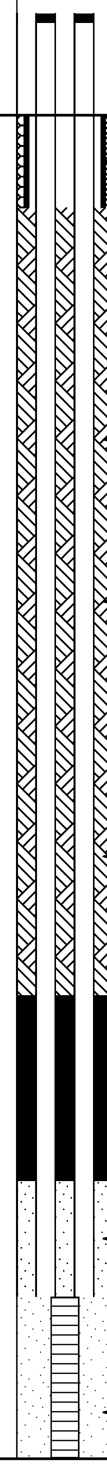
Project No.:	TR0136	**Location:**	Site 16 Landfill
Client:	Longhorn Army Ammunition Plant	**Coordinates:**	N 6,953,673.1 E 3,314,012.4
Geologist:	N. Barros	**Drilling Method:**	Hollow Stem Augers
Drilling Company:	ETTL Drilling Services	**Well Material:**	4 inch PVC Vee-Wire Wrap
Completion Date:	23 June 2003	**Borehole Diameter:**	8.5 inches
		Site Datum:	Site 16 Landfill Benchmark

Depth, feet	Depth, metres	Lithologic Description	Unified Soil Classification
0–3		no samples recovered	
3–8.8	1, 2	silt, some clay, trace sand, fine, stiff, mottled red-brown and grey, dry to moist mottled brown and black	MLCS
8.8–9.2		silty sand, fine to medium, loose, mottled brown grey, dry to moist	SM
9.2–12.6	3	clayey sand, fine to medium, stiff, mottled brown and grey, moist clay lenses	SC
12.6–14.5	4	silty sand, trace clay, fine to medium, loose, grey, moist to wet medium to coarse, very loose, brown grey, very wet	SM

Columns also headed: Water Level; Stratigraphy; Geologic Samples: Recovery, %; PID (ppmv); Soil Sample ID; Well Configuration.

Elevations (ft amsl) and Comments

Ground Surface	187.2
Top PVC Casing	190.4



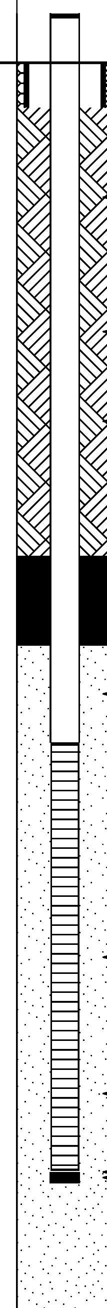
Project No.:	TR0136	**Location:**	Site 16 Landfill
Client:	Longhorn Army Ammunition Plant	**Coordinates:**	N 6,953,673.1 E 3,314,012.4
Geologist:	N. Barros	**Drilling Method:**	Hollow Stem Augers
		Well Material:	4 inch PVC Vee-Wire Wrap
Drilling Company:	ETTL Drilling Services	**Borehole Diameter:**	8.5 inches
Completion Date:	23 June 2003	**Site Datum:**	Site 16 Landfill Benchmark

Depth, feet	Depth, metres	Water Level	Stratigraphy	Lithologic Description	Unified Soil Classification	Recovery, %	PID (ppmv)	Soil Sample ID	Well Configuration	Elevations (ft amsl) and Comments: Ground Surface 187.2; Top PVC Casing 190.4
15				clay lens (15' - 15'2")	SM					16PM07-S: 1 inch diameter schedule 40 PVC screen (0.010 inch slotted)
		8-Mar-2005		sandy clay, fine to medium, very stiff, brown and grey, moist to wet	CLS					
16	5			silty clay, fine, very stiff, mottled grey and brown, moist	CLM					
17										bottom of screen; end cap; 20/40 filter sand
18				sandy clay, some silt, medium, loose, brown and grey, moist to wet	CLMS					
19										bentonite pellets
19.3				clay, trace silt, fine, very stiff, mottled grey and brown, moist	CL					
20	6									
21										20/40 filter sand
22				sandy clay						
22.5				silty sand, some clay, medium to coarse, loose, grey, wet brown, clay lenses	SM CLS					
23	7									20/40 filter sand
24										16PM07-D: 1 inch diameter schedule 40 PVC screen (0.010 inch slotted)
25										
26	8									bottom of screen; end cap
27				clayey sand, some silt, medium, loose, mottled brown and grey, moist	SC SM					
28				Borehole depth 28.0 ft (28.0 m)						

Borehole No. 16PM08

Borehole Log

Project No.:	TR0136	**Location:**	Site 16 Landfill
Client:	Longhorn Army Ammunition Plant	**Coordinates:**	N 6,953,703.7 E 3,314,013.7
Geologist:	N. Barros	**Drilling Method:**	Hollow Stem Augers
		Well Material:	4 inch PVC Vee-Wire Wrap
Drilling Company:	ETTL Drilling Services	**Borehole Diameter:**	8.5 inches
Completion Date:	25 June 2003	**Site Datum:**	Site 16 Landfill Benchmark

Depth, feet	Depth, metres	Water Level	Stratigraphy	Lithologic Description	Unified Soil Classification	Recovery, %	PID (ppmv)	Soil Sample ID	Well Configuration	Elevations (ft amsl) and Comments
										Ground Surface 187.6
										Top PVC Casing 191.0
0–28	0–8.5	8-Mar-2005 (at ~15.2 ft)		no samples recovered						
28				Borehole depth 28.0 ft (28.0 m)						

Depth scale (feet): 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29

Depth scale (metres): 1, 2, 3, 4, 5, 6, 7, 8, 9

Borehole No. 16PM09

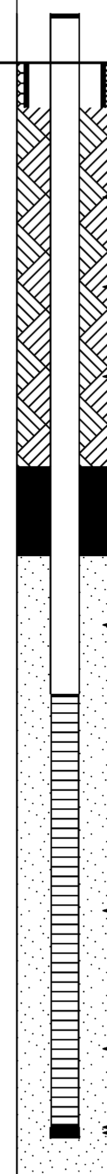
Borehole Log

Project No.:	TR0136	**Location:**	Site 16 Landfill
Client:	Longhorn Army Ammunition Plant	**Coordinates:**	N 6,953,609.7 E 3,314,011.0
Geologist:	D. Bertrand	**Drilling Method:**	Hollow Stem Augers
		Well Material:	4 inch PVC Vee-Wire Wrap
Drilling Company:	ETTL Drilling Services	**Borehole Diameter:**	8.5 inches
Completion Date:	24 June 2003	**Site Datum:**	Site 16 Landfill Benchmark

Depth, feet	Depth, metres	Water Level	Stratigraphy	Lithologic Description	Unified Soil Classification	Recovery, %	PID (ppmv)	Soil Sample ID	Well Configuration	Elevations (ft amsl) and Comments
										Ground Surface 185.5
										Top PVC Casing 188.3
0–25	0–7.6	8-Mar-2005 (at ~12.7 ft)		no samples recovered						cement surface seal; drilled hole 8.5 inches in diameter; portland cement with 8% bentonite; 2 inch diameter well casing; bentonite pellets; 20/40 filter sand; 2 inch diameter schedule 40 PVC screen (0.010 inch slotted); 20/40 filter sand; bottom screen end cap
25				Borehole depth 25.0 ft (25.0 m)						

Depth scale, feet: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29

Depth scale, metres: 1 2 3 4 5 6 7 8 9



cement surface seal

drilled hole 8.5 inches in diameter

portland cement with 8% bentonite

2 inch diameter well casing

bentonite pellets

20/40 filter sand

2 inch diameter schedule 40 PVC screen (0.010 inch slotted)

20/40 filter sand

bottom screen end cap

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Borehole No. 16PM10

Borehole Log

Project No.:	TR0136	**Location:**	Site 16 Landfill
Client:	Longhorn Army Ammunition Plant	**Coordinates:**	N 6,953,667.1 E 3,314,019.6
Geologist:	N. Barros	**Drilling Method:**	Hollow Stem Augers
Drilling Company:	ETTL Drilling Services	**Well Material:**	4 inch PVC Vee-Wire Wrap
Completion Date:	24 June 2003	**Borehole Diameter:**	8.5 inches
		Site Datum:	Site 16 Landfill Benchmark

Depth, feet	Depth, metres	Water Level	Stratigraphy	Lithologic Description	Unified Soil Classification	Recovery, %	PID (ppmv)	Soil Sample ID	Comments
0–3				no samples recovered					
3–4.25	1			silt, some clay, trace sand, fine, firm, mottled brown, grey, black and red, dry to moist, roots	MLCS				
4.25–6				silty clay, firm, brown grey red, moist silty sand (4'3.5" - 4'7") silty sand, some clay (5'2" - 5'4")	CLM				
6–8	2			clayey silt, fine, stiff, brown and grey, moist	MLC				
8–12.2	3			silty clay, fine, firm, mottled brown grey red, moist to wet more clay (10'5" - 12'2")	CLM				
12.2–15	4			silty sand, medium to coarse, loose, brown and grey, moist to wet	SM				

Report: LONGHORN; File: P:\PRJ\GINT\PROJECTS\LONGHORN.GPJ; 5/31/2005

Borehole No. 16PM10

Borehole Log

Project No.: TR0136
Client: Longhorn Army Ammunition Plant
Geologist: N. Barros
Drilling Company: ETTL Drilling Services
Completion Date: 24 June 2003

Location: Site 16 Landfill
Coordinates: N 6,953,667.1 E 3,314,019.6
Drilling Method: Hollow Stem Augers
Well Material: 4 inch PVC Vee-Wire Wrap
Borehole Diameter: 8.5 inches
Site Datum: Site 16 Landfill Benchmark

Depth, feet	Depth, metres	Water Level	Stratigraphy	Lithologic Description	Unified Soil Classification	Recovery, %	PID (ppmv)	Soil Sample ID	Comments
16–17	5			sandy clay layer (15'2" - 15'9") sandy clay layer (16'5" - 17'1") oxidized sand, red (17'1" - 17'5")	SM				
18				clay, some sand surround core, medium to coarse, very stiff, brown red, moist	CL				
				silty sand, medium, very loose, grey, wet some clay (18'8" - 18'10")	SM				
19–22	6			silty clay, fine, firm, mottled brown, grey and red, dry to moist more silt (20'2" - 20'11")	CLM				
23	7			clayey silt, some sand, fine to medium, brown and grey	MLC				
24–28	8			silty sand, medium, well sorted, very loose, brown and grey, very wet	SM				
28–29	9			Borehole depth 28.0 ft (28.0 m)					

Borehole No. 16PM10D

Borehole Log

Project No.:	TR0136	**Location:**	Site 16 Landfill
Client:	Longhorn Army Ammunition Plant	**Coordinates:**	N 6,953,667.1 E 3,314,019.6
Geologist:	N. Barros	**Drilling Method:**	Hollow Stem Augers
		Well Material:	4 inch PVC Vee-Wire Wrap
Drilling Company:	ETTL Drilling Services	**Borehole Diameter:**	8.5 inches
Completion Date:	24 June 2003	**Site Datum:**	Site 16 Landfill Benchmark

Depth, feet	Depth, metres	Water Level	Lithologic Description	Unified Soil Classification	Recovery, %	PID (ppmv)	Soil Sample ID	Elevations (ft amsl) and Comments
								Ground Surface 186.3; Top PVC Casing 189.6
0–3			no samples recovered					cement surface seal
3–4.25	1		silt, some clay, trace sand, fine, firm, mottled brown, grey, black and red, dry to moist, roots	MLCS	85	NA	SS-1	drilled hole 8.5 inches in diameter
4.25–6			silty clay, firm, brown grey red, moist; silty sand (4'3.5" - 4'7"); silty sand, some clay (5'2" - 5'4")	CLM				portland cement with 8% bentonite
6–8	2		clayey silt, fine, stiff, brown and grey, moist	MLC				1 inch diameter well casing
8–12.2	3		silty clay, fine, firm, mottled brown grey red, moist to wet; more clay (10'5" - 12'2")	CLM	98	NA	SS-2	bentonite pellets; 20/40 filter sand
12.2–15	4	8-Mar-2005	silty sand, medium to coarse, loose, brown and grey, moist to wet	SM				20/40 filter sand

Borehole No. 16PM10D

Borehole Log

Project No.: TR0136
Client: Longhorn Army Ammunition Plant
Geologist: N. Barros
Drilling Company: ETTL Drilling Services
Completion Date: 24 June 2003
Location: Site 16 Landfill
Coordinates: N 6,953,667.1 E 3,314,019.6
Drilling Method: Hollow Stem Augers
Well Material: 4 inch PVC Vee-Wire Wrap
Borehole Diameter: 8.5 inches
Site Datum: Site 16 Landfill Benchmark

Elevations (ft amsl) and Comments: Ground Surface 186.3; Top PVC Casing 189.6

Depth, feet	Lithologic Description	Unified Soil Classification	Recovery, %	PID (ppmv)	Soil Sample ID	Elevations (ft amsl) and Comments
15–17.4	sandy clay layer (15'2" - 15'9") sandy clay layer (16'5" - 17'1") oxidized sand, red (17'1" - 17'5")	SM	93	NA	SS-3	16PM10-S: 1 inch diameter schedule 40 PVC screen (0.010 inch slotted); bottom of screen; end cap; 20/40 filter sand
17.4–18	clay, some sand surround core, medium to coarse, very stiff, brown red, moist	CL				
18–18.8	silty sand, medium, very loose, grey, wet some clay (18'8" - 18'10")	SM	100	NA	SS-4	bentonite pellets
18.8–22.6	silty clay, fine, firm, mottled brown, grey and red, dry to moist more silt (20'2" - 20'11")	CLM				20/40 filter sand
22.6–23	clayey silt, some sand, fine to medium, brown and grey	MLC				
23–28	silty sand, medium, well sorted, very loose, brown and grey, very wet	SM	80	NA	SS-5	20/40 filter sand; 16PM10-D: 1 inch diameter schedule 40 PVC screen (0.010 inch slotted); bottom of screen; end cap
28	Borehole depth 28.0 ft (28.0 m)					

Depth, metres: 5 (at ~16.4 ft), 6 (~19.7 ft), 7 (~23 ft), 8 (~26.2 ft), 9 (~29.5 ft)

Borehole No. 16PM10S

Borehole Log

Project No.:	TR0136	**Location:**	Site 16 Landfill
Client:	Longhorn Army Ammunition Plant	**Coordinates:**	N 6,953,657.1 E 3,314,019.6
Geologist:	D. Bertrand	**Drilling Method:**	Hollow Stem Augers
		Well Material:	4 inch PVC Vee-Wire Wrap
Drilling Company:	ETTL Drilling Services	**Borehole Diameter:**	8.5 inches
Completion Date:	24 June 2003	**Site Datum:**	Site 16 Landfill Benchmark

Depth, feet	Depth, metres	Water Level	Stratigraphy	Lithologic Description	Unified Soil Classification	Recovery, %	PID (ppmv)	Soil Sample ID	Well Configuration	Elevations (ft amsl) and Comments
										Ground Surface 186.3
										Top PVC Casing 189.6
0–3				no samples recovered						cement surface seal
3–4.25	1			silt, some clay, trace sand, fine, firm, mottled brown, grey, black and red, dry to moist, roots	MLCS					drilled hole 8.5 inches in diameter
4.25–6				silty clay, firm, brown grey red, moist silty sand (4'3.5" - 4'7") silty sand, some clay (5'2" - 5'4")	CLM					portland cement with 8% bentonite
6–8	2			clayey silt, fine, stiff, brown and grey, moist	MLC					1 inch diameter well casing
8–12.2	3			silty clay, fine, firm, mottled brown grey red, moist to wet more clay (10'5" - 12'2")	CLM					bentonite pellets 20/40 filter sand
12.2–15	4	8-Mar-2005		silty sand, medium to coarse, loose, brown and grey, moist to wet	SM					20/40 filter sand

Project No.:	TR0136	**Location:**	Site 16 Landfill
Client:	Longhorn Army Ammunition Plant	**Coordinates:**	N 6,953,657.1 E 3,314,019.6
Geologist:	D. Bertrand	**Drilling Method:**	Hollow Stem Augers
Drilling Company:	ETTL Drilling Services	**Well Material:**	4 inch PVC Vee-Wire Wrap
Completion Date:	24 June 2003	**Borehole Diameter:**	8.5 inches
		Site Datum:	Site 16 Landfill Benchmark

Depth, feet	Depth, metres	Water Level	Stratigraphy	Lithologic Description	Unified Soil Classification	Recovery, %	PID (ppmv)	Soil Sample ID	Well Configuration	Elevations (ft amsl) and Comments
										Ground Surface 186.3
										Top PVC Casing 189.6
15–17.5	5			sandy clay layer (15'2" - 15'9") sandy clay layer (16'5" - 17'1") oxidized sand, red (17'1" - 17'5")	SM					16PM10-S: 1 inch diameter schedule 40 PVC screen (0.010 inch slotted)
17.5–18				clay, some sand surround core, medium to coarse, very stiff, brown red, moist	CL					bottom of screen end cap 20/40 filter sand
18–18.8				silty sand, medium, very loose, grey, wet some clay (18'8" - 18'10")	SM					
18.8–22.5	6			silty clay, fine, firm, mottled brown, grey and red, dry to moist more silt (20'2" - 20'11")	CLM					bentonite pellets 20/40 filter sand
22.5–23	7			clayey silt, some sand, fine to medium, brown and grey	MLC					20/40 filter sand
23–28	8			silty sand, medium, well sorted, very loose, brown and grey, very wet	SM					16PM10-D: 1 inch diameter schedule 40 PVC screen (0.010 inch slotted) bottom of screen end cap
28	9			Borehole depth 28.0 ft (28.0 m)						

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Borehole No. 16PM11

Borehole Log

Project No.: TR0136

Client: Longhorn Army Ammunition Plant

Geologist: N. Barros

Drilling Company: ETTL Drilling Services

Completion Date: 25 June 2003

Location: Site 16 Landfill

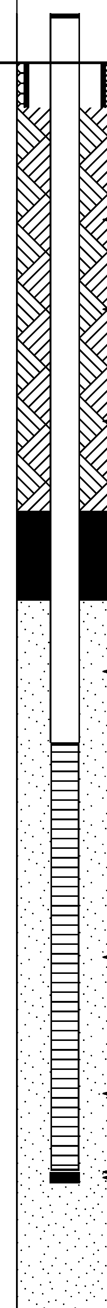
Coordinates: N 6,953,701.7 E 3,314,023.7

Drilling Method: Hollow Stem Augers

Well Material: 4 inch PVC Vee-Wire Wrap

Borehole Diameter: 8.5 inches

Site Datum: Site 16 Landfill Benchmark

Depth			Stratigraphy	Lithologic Description	Geologic Samples				Well Configuration	Elevations (ft amsl) and Comments
Depth, feet	Depth, metres	Water Level			Unified Soil Classification	Recovery, %	PID (ppmv)	Soil Sample ID		Ground Surface 187.9; Top PVC Casing 190.9
0–28	0–8.5	▼ 8-Mar-2005 (at ~15.8 ft)		no samples recovered						cement surface seal; drilled hole 8.5 inches in diameter; portland cement with 8% bentonite; 2 inch diameter well casing; bentonite pellets; 20/40 filter sand; 2 inch diameter schedule 40 PVC screen (0.010 inch slotted); 20/40 filter sand; bottom screen end cap
28				Borehole depth 28.0 ft (28.0 m)						

Depth, feet scale: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29

Depth, metres scale: 1, 2, 3, 4, 5, 6, 7, 8, 9

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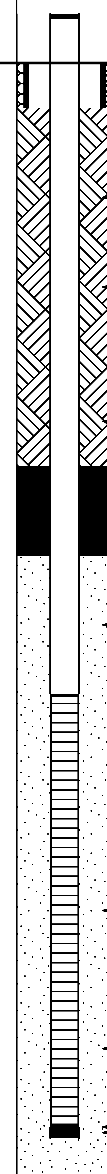
Borehole No. 16PM12

Borehole Log

Project No.:	TR0136	**Location:**	Site 16 Landfill
Client:	Longhorn Army Ammunition Plant	**Coordinates:**	N 6,953,609.9 E 3,314,021.1
Geologist:	N. Barros	**Drilling Method:**	Hollow Stem Augers
Drilling Company:	ETTL Drilling Services	**Well Material:**	4 inch PVC Vee-Wire Wrap
Completion Date:	24 June 2003	**Borehole Diameter:**	8.5 inches
		Site Datum:	Site 16 Landfill Benchmark

Depth, feet	Depth, metres	Water Level	Stratigraphy	Lithologic Description	Unified Soil Classification	Recovery, %	PID (ppmv)	Soil Sample ID	Well Configuration	Elevations (ft amsl) and Comments
										Ground Surface 185.2
										Top PVC Casing 188.1
0–25	0–7.6	8-Mar-2005 (at ~13 ft)		no samples recovered						cement surface seal; drilled hole 7 inches in diameter; portland cement with 8% bentonite; 2 inch diameter well casing; bentonite pellets; 20/40 filter sand; 2 inch diameter schedule 40 PVC screen (0.010 inch slotted); 20/40 filter sand; bottom screen end cap
25				Borehole depth 25.0 ft (25.0 m)						



Borehole No. 16PM13D

Borehole Log

Project No.: TR0136
Client: Longhorn Army Ammunition Plant
Geologist: N. Barros
Drilling Company: ETTL Drilling Services
Completion Date: 25 June 2003

Location: Site 16 Landfill
Coordinates: N 6,953,683.2 E 3,314,034.5
Drilling Method: Hollow Stem Augers
Well Material: 4 inch PVC Vee-Wire Wrap
Borehole Diameter: 8.5 inches
Site Datum: Site 16 Landfill Benchmark

Elevations (ft amsl) and Comments: Ground Surface 186.9; Top PVC Casing 189.8

Depth, feet	Depth, metres	Water Level	Stratigraphy	Lithologic Description	Unified Soil Classification	Recovery, %	PID (ppmv)	Soil Sample ID	Well Configuration	Elevations (ft amsl) and Comments
0–3				no samples recovered						cement surface seal
3–4.5	1			silty clay, fine, stiff, brown, grey and red, roots, dry to moist	CLM	97	NA	SS-1		drilled hole 8.5 inches in diameter
4.5–7	2			clayey silt, fine, stiff, grey, red and orange	MLC					portland cement with 8% bentonite
7–8				silty clay, brown and grey, dry to moist silt layer (7' - 7'2")	CLM					1 inch diameter well casing
8–10.75	3			clayey silt	ML	97	NA	SS-2		bentonite pellets
10.75–11.7				silty clay, stiff, moist	CLM					20/40 filter sand
11.7–13				sandy silt, fine to medium, loose, brown and grey, moist to wet sandy clay (12'4" - 12'8")	MLS					
13–13.4	4			clayey silt, some sand moist	MLC					
13.4–14.5				silty sand, medium to coarse, very loose, brown and grey, wet, some roots	SM					20/40 filter sand

Project No.:	TR0136	**Location:**	Site 16 Landfill
Client:	Longhorn Army Ammunition Plant	**Coordinates:**	N 6,953,683.2 E 3,314,034.5
Geologist:	N. Barros	**Drilling Method:**	Hollow Stem Augers
Drilling Company:	ETTL Drilling Services	**Well Material:**	4 inch PVC Vee-Wire Wrap
Completion Date:	25 June 2003	**Borehole Diameter:**	8.5 inches
		Site Datum:	Site 16 Landfill Benchmark

Elevations (ft amsl) and Comments: Ground Surface 186.9; Top PVC Casing 189.8

Depth, feet	Depth, metres	Water Level	Lithologic Description	Unified Soil Classification	Recovery, %	PID (ppmv)	Soil Sample ID	Elevations (ft amsl) and Comments
14.5–14.8		▼ 8-Mar-2005	clayey sand (14'6" - 14'10")	SM	60	NA	SS-3	
15			sand, some silt and clay, medium to coarse, very loose, brown and red, moist	SPMC				16PM13-S: 1 inch diameter schedule 40 PVC screen (0.010 inch slotted)
16	5		sandy silt, medium, very loose, brown grey, wet	SM				bottom of screen; end cap; 20/40 filter sand
18					100	NA	SS-4	bentonite pellets
19	6		clayey sand, medium, mottled brown and grey, moist to wet clay lens (19'6" - 19'10")	SC				
20			silty clay, trace sand, fine very stiff, mottled brown grey, moist	CLM				20/40 filter sand
22	7		clayey silt, fine to medium, firm, mottled brown grey, moist, black grains	MLC				
23			silty sand, very loose, brown grey, wet some clay (24'2" - 24'4") change in colour to mottled red brown grey (24'4")	SM	73	NA	SS-5	20/40 filter sand 16PM13-D: 1 inch diameter schedule 40 PVC screen (0.010 inch slotted) bottom of screen; end cap
28			Borehole depth 28.0 ft (28.0 m)					

Borehole No. 16PM13S

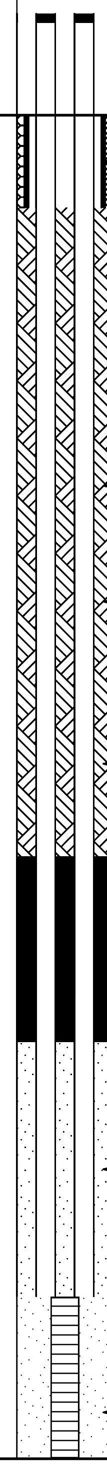
Borehole Log

Project No.: TR0136
Client: Longhorn Army Ammunition Plant
Geologist: N. Barros
Drilling Company: ETTL Drilling Services
Completion Date: 25 June 2003

Location: Site 16 Landfill
Coordinates: N 6,953,673.2 E 3,314,034.5
Drilling Method: Hollow Stem Augers
Well Material: 4 inch PVC Vee-Wire Wrap
Borehole Diameter: 8.5 inches
Site Datum: Site 16 Landfill Benchmark

Depth, feet	Depth, metres	Water Level	Stratigraphy	Lithologic Description	Unified Soil Classification	Recovery, %	PID (ppmv)	Soil Sample ID
0 – 3				no samples recovered				
3 – 4.5	1			silty clay, fine, stiff, brown, grey and red, roots, dry to moist	CLM			
4.5 – 7	2			clayey silt, fine, stiff, grey, red and orange	MLC			
7 – 8				silty clay, brown and grey, dry to moist silt layer (7' - 7'2")	CLM			
8 – 10.75	3			clayey silt	ML			
10.75 – 11.7				silty clay, stiff, moist	CLM			
11.7 – 13				sandy silt, fine to medium, loose, brown and grey, moist to wet sandy clay (12'4" - 12'8")	MLS			
13 – 13.4	4			clayey silt, some sand moist	MLC			
13.4 – 14.5				silty sand, medium to coarse, very loose, brown and grey, wet, some roots	SM			

Well Configuration



Elevations (ft amsl) and Comments

Ground Surface	186.9
Top PVC Casing	189.8

- cement surface seal
- drilled hole 8.5 inches in diameter
- portland cement with 8% bentonite
- 1 inch diameter well casing
- bentonite pellets
- 20/40 filter sand
- 20/40 filter sand

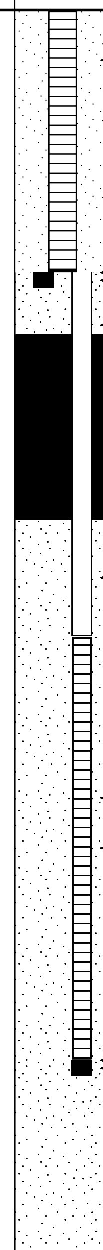
Borehole No. 16PM13S

Borehole Log

Project No.:	TR0136	**Location:**	Site 16 Landfill
Client:	Longhorn Army Ammunition Plant	**Coordinates:**	N 6,953,673.2 E 3,314,034.5
Geologist:	N. Barros	**Drilling Method:**	Hollow Stem Augers
		Well Material:	4 inch PVC Vee-Wire Wrap
Drilling Company:	ETTL Drilling Services	**Borehole Diameter:**	8.5 inches
Completion Date:	25 June 2003	**Site Datum:**	Site 16 Landfill Benchmark

Depth, feet	Depth, metres	Water Level	Lithologic Description	Unified Soil Classification	Recovery, %	PID (ppmv)	Soil Sample ID
			clayey sand (14'6" - 14'10")	SM			
15		▼ 8-Mar-2005	sand, some silt and clay, medium to coarse, very loose, brown and red, moist	SPMC			
16–19	5		sandy silt, medium, very loose, brown grey, wet	SM			
19–20	6		clayey sand, medium, mottled brown and grey, moist to wet clay lens (19'6" - 19'10")	SC			
20–22			silty clay, trace sand, fine very stiff, mottled brown grey, moist	CLM			
23	7		clayey silt, fine to medium, firm, mottled brown grey, moist, black grains	MLC			
23–28	8		silty sand, very loose, brown grey, wet some clay (24'2" - 24'4") change in colour to mottled red brown grey (24'4")	SM			
28			Borehole depth 28.0 ft (28.0 m)				

Well Configuration



Elevations (ft amsl) and Comments

Ground Surface 186.9

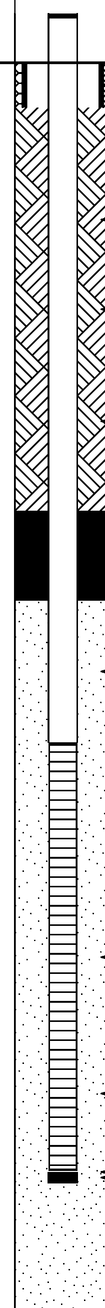
Top PVC Casing 189.8

Borehole No. 16PM14

Borehole Log

Project No.:	TR0136	**Location:**	Site 16 Landfill
Client:	Longhorn Army Ammunition Plant	**Coordinates:**	N 6,953,701.6 E 3,314,034.4
Geologist:	N. Barros	**Drilling Method:**	Hollow Stem Augers
		Well Material:	4 inch PVC Vee-Wire Wrap
Drilling Company:	ETTL Drilling Services	**Borehole Diameter:**	8.5 inches
Completion Date:	25 June 2003	**Site Datum:**	Site 16 Landfill Benchmark

Depth, feet	Depth, metres	Water Level	Stratigraphy	Lithologic Description	Unified Soil Classification	Recovery, %	PID (ppmv)	Soil Sample ID	Well Configuration	Elevations (ft amsl) and Comments
										Ground Surface 188.2
										Top PVC Casing 191.2
0				no samples recovered						cement surface seal
3.5	1									drilled hole 8.5 inches in diameter
5.5	2									portland cement with 8% bentonite
8										2 inch diameter well casing
11	3									bentonite pellets
13.5	4									20/40 filter sand
16	5	▼ 8-Mar-2005								
20	6									2 inch diameter schedule 40 PVC screen (0.010 inch slotted)
23	7									20/40 filter sand
25										bottom screen end cap
28	8			Borehole depth 28.0 ft (28.0 m)						
29	9									



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Borehole No. BH-4 (Background)

Borehole Log

Project No.:	TR0136	**Location:**	Site 16 Landfill
Client:	Longhorn Army Ammunition Plant	**Coordinates:**	
Geologist:	D. Bertrand	**Drilling Method:**	Hollow Stem Augers
Drilling Company:	ETTL Drilling Services	**Well Material:**	4 inch PVC Vee-Wire Wrap
Completion Date:	26 March 2003	**Borehole Diameter:**	6.75 inches
		Site Datum:	Site 16 Landfill Benchmark

Depth, feet	Depth, metres	Water Level	Stratigraphy	Lithologic Description	Unified Soil Classification	Recovery, %	PID (ppmv)	Soil Sample ID	Comments
0–13	0–4			no samples recovered					
13–14.4				clayey sand with some silt, compact, mottled light brown with grey, moist	SC	40	NA	SS-1	
14.4–18.7				silty clay, stiff, light brown with grey, moist	CL				
18.7–30.1				silty sand, fine to medium grained, well sorted, loose, light brown, moist; wet; very fine	SM	35	NA	SS-2	
						58	NA	SS-3	
30.1–31.8				silty clay, very stiff, light brown, wet	CL	87	NA	SS-4	
31.8–33				silty sand, fine to medium grained, loose, brown, wet	SM				
33				Borehole depth 33.0 ft (33.0 m)					NA - not available

Borehole No. 16BH1

Borehole Log

Project No.: TR0136
Client: Longhorn Army Ammunition Plant
Geologist: D. Bertrand
Drilling Company: ETTL Drilling Services
Completion Date: 22 February 2005
Location: Site 16 Landfill
Coordinates: N 6,953,600.9 E 3,313,994.1
Drilling Method: Hollow Stem Augers
Well Material: 4 inch PVC Vee-Wire Wrap
Borehole Diameter: 2 inches
Site Datum: Site 16 Landfill Benchmark

Depth, feet	Lithologic Description	Unified Soil Classification	Recovery, %	PID (ppmv)	Soil Sample ID	Comments
0–4	silty clay, stiff, yellowish-orange, moist	CL	75	NA		
4–8	clay, stiff, light grey, moist, mottled orange-red	CL	100	NA		
8–12	grading into silty sand, mottled orange-grey, moist	CL	100	NA		
12–16	silty sand, fine grained, loose, light brown, moist wet grading into clay, grey, wet grading into very loose sand	SM	100	NA	SS-1	
17–18	sand, very loose, grey, sewer odor	SP	100	NA	SS-2	
18–20	clay, stiff, grey	CL				
20–21.5	sand, fine grained, very loose, grey, wet	SP	100	NA	SS-3 SS-4	
21.5–24	silty clay, grey	CL				
24	Borehole depth 24.0 ft (24.0 m)					

Depth scale: 1–29 feet; 1–9 metres. Water Level and Stratigraphy columns shown graphically.

Borehole No. 16BH2

Borehole Log

Project No.: TR0136
Client: Longhorn Army Ammunition Plant
Geologist: D. Bertrand
Drilling Company: ETTL Drilling Services
Completion Date: 22 February 2005

Location: Site 16 Landfill
Coordinates: N 6,953,670.3 E 3,314,004.2
Drilling Method: Hollow Stem Augers
Well Material: 4 inch PVC Vee-Wire Wrap
Borehole Diameter: 2 inches
Site Datum: Site 16 Landfill Benchmark

Depth, feet	Lithologic Description	Unified Soil Classification	Recovery, %	PID (ppmv)	Soil Sample ID	Comments
0–2	clay, stiff to soft, tan-orange, moist	CL	75	NA		
2–4	silty clay, soft, mottled-organic	CL				
4–6	silty sand, fine grained, loose, tan, wet	SM	75	NA		
6–8	clay, stiff, mottled tan and orange, moist	CL				
8–10	silty sand, fine grained, loose, tan, wet	SM	100	NA		
10–12	silty clay, stiff, mottled tan and grey, moist	CL				
12–15	silty sand, fine grained, loose, tan, septic odour	SM	88	NA	SS-1	
15–16	silty clay, stiif, tan	CL				
16–18	silty sand, fine grained, loose, tan, wet	SM	100	NA	SS-2	
18–20	sand, medium grained, firm, dark grey, wet	SP				
20–24	silty sand, fine grained, tan-green, wet	SM	88	NA	SS-3 SS-4	
24	Borehole depth 24.0 ft (24.0 m)					

Borehole No. 16BH3

Borehole Log

Project No.: TR0136
Client: Longhorn Army Ammunition Plant
Geologist: D. Bertrand
Drilling Company: ETTL Drilling Services
Completion Date: 22 February 2005
Location: Site 16 Landfill
Coordinates: N 6,953,706.8 E 3,313,979.1
Drilling Method: Hollow Stem Augers
Well Material: 4 inch PVC Vee-Wire Wrap
Borehole Diameter: 2 inches
Site Datum: Site 16 Landfill Benchmark

Depth, feet	Lithologic Description	Unified Soil Classification	Recovery, %	PID (ppmv)	Soil Sample ID	Comments
0–2	silty clay, stiff, brown, moist	CL	50 (0–4)	NA		
2–6	silty clay, soft, brown, mottled tan and orange, organics	OL	100 (4–8)	NA		
6–7	sandy clay, fine grained, mottled grey and orange, moist	CL				
7–15	silty clay, stiff, mottled grey and orange; wet (at 12)	CL	100 (8–12); 100 (12–16)	NA; NA	SS-1, SS-2 (12–16)	
15–16	sandy clay, tan, moist	CL				
16–24	silty sand, soft, tan, wet, septic odor; orange-tan clay clasts (at 18); wet (at 20)	SM	100 (16–20); 100 (20–24)	NA; NA	SS-3, SS-4 (20–24)	
24	Borehole depth 24.0 ft (24.0 m)					

Depth scales: feet 1–29; metres 1–9.

Borehole No. 16EW09

Borehole Log

Project No.: TR0136

Client: Longhorn Army Ammunition Plant

Geologist: D. Bertrand

Drilling Company: ETTL Drilling Services

Completion Date: 25 March 2003

Location: Site 16 Landfill

Coordinates: N 6,953,647.1 E 3,314,058.7

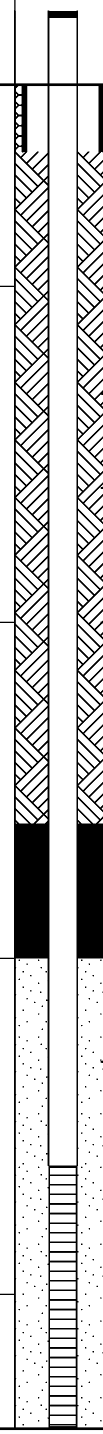
Drilling Method: Hollow Stem Augers

Well Material: 4 inch PVC Vee-Wire Wrap

Borehole Diameter: 10.25 inches

Site Datum: Site 16 Landfill Benchmark

Depth, feet	Depth, metres	Water Level	Lithologic Description	Unified Soil Classification	Recovery, %	PID (ppmv)	Soil Sample ID	Elevations (ft amsl) and Comments
								Ground Surface 187.4
								Top PVC Casing 190.4
0–3			no samples recovered					cement surface seal
3–10.6	1–3		silty clay, stiff, mottled reddish brown and grey, moist; some sand; mottled brown and grey, moist to wet	CL	73	NA	SS-1	drilled hole 10.25 inches in diameter; portland cement with 8% bentonite; 4 inch diameter well casing
10.6–13.3			silty sand, trace clay, firm, light brown with grey, wet; near bottom, no clay, light brown, very loose	SM	82	18.7	SS-2	bentonite pellets
13.3–14.1	4		clayey sand with some silt, firm, light brown, wet	SC SM				
14.1–17.4	5	8-Mar-2005	silty sand, trace clay, fine grained, very loose, light brown, very wet; fine to medium grained, loose, reddish brown, wet	SM	100	66.1	SS-3	20/40 filter sand
17.4–18			silty clay, trace sand, very stiff, mottled brown and grey, moist	CL				
18–20	6		clayey sand with some silt, fine grained, brown with pockets of grey, wet	SC SM				



Borehole No. 16EW09

Borehole Log

Project No.:	TR0136	**Location:**	Site 16 Landfill
Client:	Longhorn Army Ammunition Plant	**Coordinates:**	N 6,953,647.1 E 3,314,058.7
Geologist:	D. Bertrand	**Drilling Method:**	Hollow Stem Augers
Drilling Company:	ETTL Drilling Services	**Well Material:**	4 inch PVC Vee-Wire Wrap
Completion Date:	25 March 2003	**Borehole Diameter:**	10.25 inches
		Site Datum:	Site 16 Landfill Benchmark

Depth, feet	Depth, metres	Water Level	Stratigraphy	Lithologic Description	Unified Soil Classification	Recovery, %	PID (ppmv)	Soil Sample ID	Well Configuration	Elevations (ft amsl) and Comments
										Ground Surface 187.4; Top PVC Casing 190.4
20–21					SC SM	100	NA	SS-4		4 inch diameter schedule 40 PVC screen (0.010 inch slotted)
21–23	7			silty clay, very stiff, brown, some pockets of grey	CL					20/40 filter sand
23–25				clayey sand, firm, light brown, wet	SC					
25–26.8	8			silty sand, trace clay, loose, brown-grey, wet	SM	83	NA	SS-5		bottom of screen; end cap
26.8–28				clayey sand, firm, mottled brown and grey, moist	SC					
28	9, 10, 11, 12			Borehole depth 28.0 ft (28.0 m)						NA - not available

Borehole No. 16EW10

Borehole Log

Project No.:	TR0136	**Location:**	Site 16 Landfill
Client:	Longhorn Army Ammunition Plant	**Coordinates:**	N 6,953,687.9 E 3,314,023.0
Geologist:	D. Bertrand	**Drilling Method:**	Hollow Stem Augers
Drilling Company:	ETTL Drilling Services	**Well Material:**	4 inch PVC Vee-Wire Wrap
Completion Date:	25 March 2003	**Borehole Diameter:**	10.25 inches
		Site Datum:	Site 16 Landfill Benchmark

Depth, feet	Depth, metres	Water Level	Lithologic Description	Unified Soil Classification	Recovery, %	PID (ppmv)	Soil Sample ID	Elevations (ft amsl) and Comments
								Ground Surface 187.7
								Top PVC Casing 190.5
0–3			no samples recovered					cement surface seal
3–7	1		silty clay, mottled reddish brown and grey, moist; some sand	CL	100	NA	SS-1	drilled hole 10.25 inches in diameter; portland cement with 8% bentonite
7–8	2		silty sand, trace clay, loose, brown-grey, dry to moist	SM				
8–9.5			silty clay, fine to medium grained, stiff, mottled brown and grey, wet	CL	55	NA	SS-2	4 inch diameter well casing
9.5–20	3–6	▼ 8-Mar-2005 (approx. 15 ft)	silty sand, fine to medium grained, loose, light brown, wet; trace clay, fine grained, very wet (13 ft); some clay (17 ft); fine to medium grained, wet (18 ft); some clay, brown-grey (20 ft)	SM	77 (13–18 ft)	NA	SS-3	bentonite pellets; 20/40 filter sand

Borehole No. 16EW10

Borehole Log

Project No.: TR0136
Client: Longhorn Army Ammunition Plant
Geologist: D. Bertrand
Drilling Company: ETTL Drilling Services
Completion Date: 25 March 2003

Location: Site 16 Landfill
Coordinates: N 6,953,687.9 E 3,314,023.0
Drilling Method: Hollow Stem Augers
Well Material: 4 inch PVC Vee-Wire Wrap
Borehole Diameter: 10.25 inches
Site Datum: Site 16 Landfill Benchmark

Elevations (ft amsl) and Comments: Ground Surface 187.7; Top PVC Casing 190.5

Depth, feet	Depth, metres	Lithologic Description	Unified Soil Classification	Recovery, %	PID (ppmv)	Soil Sample ID	Comments
20–22			SM	100	NA	SS-4	
22–23		silty clay, stiff, brown-grey, wet	CL				
23–33	7–10	silty sand, trace clay, fine to medium grained, light brown, loose, very wet	SM	83	NA	SS-5	4 inch diameter schedule 40 PVC screen (0.010 inch slotted); 20/40 filter sand
27.3		no clay, loose					bottom of screen; end cap
28–33				10	NA	SS-6	
33	10	Borehole depth 33.0 ft (33.0 m)					

NA - not available

Borehole No. 16EW11

Borehole Log

Project No.:	TR0136	**Location:**	Site 16 Landfill
Client:	Longhorn Army Ammunition Plant	**Coordinates:**	N 6,953,739.9 E 3,314,010.7
Geologist:	D. Bertrand	**Drilling Method:**	Hollow Stem Augers
Drilling Company:	ETTL Drilling Services	**Well Material:**	4 inch PVC Vee-Wire Wrap
Completion Date:	26 March 2003	**Borehole Diameter:**	10.25 inches
		Site Datum:	Site 16 Landfill Benchmark

Depth: Depth, feet (1–19); Depth, metres (1–6); Water Level: 8-Mar-2005 (about 18 ft)

Lithologic Description	Unified Soil Classification	Recovery, %	PID (ppmv)	Soil Sample ID
no samples recovered				
silty clay, stiff, mottled brown and grey, moist	CL	92	NA	SS-1
silty sand with trace clay, fine grained, loose, light brown, moist	SM			
silty clay with trace sand, stiff, light brown with some grey pockets, moist some sand, mottled brown and grey no sand, firm	CL			
silty sand, trace clay, firm, brown-grey, moist some clay	SM	100	NA	SS-2
clayey silt, trace sand, stiff, brown-grey, moist	CL			
silty sand, fine to medium grained, brown, loose, moist	SM			
clayey sand, some silt, fine grained, firm, brown, moist and wet	SC			
silty sand, fine to medium grained, loose, dark brown, moist	SM	100	NA	SS-3
silty clay, stiff, light brown, moist	CL			
silty sand, fine grained, loose, light brown, wet very wet very loose, very wet	SM			

Elevations (ft amsl) and Comments

Ground Surface	190.4
Top PVC Casing	193.4

Well Configuration:
- cement surface seal
- drilled hole 10.75 inches in diameter
- 4 inch diameter well casing
- portland cement with 8% bentonite
- bentonite pellets
- 20/40 filter sand

Borehole No. 16EW11

Borehole Log

Project No.:	TR0136	**Location:**	Site 16 Landfill
Client:	Longhorn Army Ammunition Plant	**Coordinates:**	N 6,953,739.9 E 3,314,010.7
Geologist:	D. Bertrand	**Drilling Method:**	Hollow Stem Augers
Drilling Company:	ETTL Drilling Services	**Well Material:**	4 inch PVC Vee-Wire Wrap
Completion Date:	26 March 2003	**Borehole Diameter:**	10.25 inches
		Site Datum:	Site 16 Landfill Benchmark

Depth, feet	Depth, metres	Water Level	Stratigraphy	Lithologic Description	Unified Soil Classification	Recovery, %	PID (ppmv)	Soil Sample ID	Well Configuration	Elevations (ft amsl) and Comments
										Ground Surface 190.4 Top PVC Casing 193.4
20.3–21				silty clay, hard, light brown, wet	CL	100	NA	SS-4		
21–23				clayey sand, some silt, compact, light brown with small pockets of grey, wet	SC					20/40 filter sand
23–24.7	7			silty sand, trace clay, fine grained, loose, brown, very wet	SM	100	NA	SS-5		
24.7–27.8	8			silty clay, hard, mottled brown and grey, moist to wet	CL					4 inch diameter schedule 40 PVC screen (0.010 inch slotted)
27.8–28.5				clayey sand with some silt, loose, light brown, wet	SC					
28.5–33	9, 10			silty sand, trace clay, loose, light brown-grey, wet brown	SM	100	NA	SS-6		bottom screen end cap
33				Borehole depth 33.0 ft (33.0 m)						

Depth scale: 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39 feet; 7, 8, 9, 10, 11, 12 metres.

NA - not available

Borehole No. 16EW12

Borehole Log

Project No.: TR0136
Client: Longhorn Army Ammunition Plant
Geologist: N. Barros
Drilling Company: ETTL Drilling Services
Completion Date: 23 June 2003
Location: Site 16 Landfill
Coordinates: N 6,953,704.4 E 3,314,004.6
Drilling Method: Hollow Stem Augers
Well Material: 4 inch PVC Vee-Wire Wrap
Borehole Diameter: 10 inches
Site Datum: Site 16 Landfill Benchmark

Elevations (ft amsl) and Comments: Ground Surface 187.2; Top PVC Casing 190.4

Depth, feet	Lithologic Description	Unified Soil Classification	Recovery, %	PID (ppmv)	Soil Sample ID	Comments
0–1	clayey silt, firm, brown, moist, roots	MLC	100	NA	SS-1	cement surface seal
1–2	dark brown, dry to moist	MLC				
2–4.8	sandy silt, medium, compact, brown red grey, dry to moist	SM	98	NA	SS-2	drilled hole 10 inches in diameter
4.8–5.7	clayey silt, mottled light brown and grey, dry to moist	MLC				portland cement with 8% bentonite
5.7–7	silty clay, fine, very stiff, light brown grey, moist	CLM				
7–8	clay, very stiff, mottled brown and grey, moist	CL				4 inch diameter well casing
8–10.2	clay, some sand, fine to medium, firm, mottled light brown and grey, moist to wet	CLS	93	NA	SS-3	
10.2–12.2	silt, some clay, very loose, brown, moist	MLC				bentonite pellets
12.2–12.7	silty clay, some sand, firm, light brown, dry to moist	CLMS				
12.7–	silt, some clay, very loose, grey, wet	MLC				20/40 filter sand

Borehole No. 16PM14

Borehole Log

Project No.: TR0136

Client: Longhorn Army Ammunition Plant

Geologist: N. Barros

Drilling Company: ETTL Drilling Services

Completion Date: 25 June 2003

Location: Site 16 Landfill

Coordinates: N 6,953,701.6 E 3,314,034.4

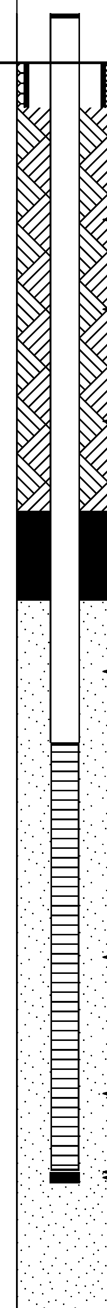
Drilling Method: Hollow Stem Augers

Well Material: 4 inch PVC Vee-Wire Wrap

Borehole Diameter: 8.5 inches

Site Datum: Site 16 Landfill Benchmark

Depth, feet	Depth, metres	Water Level	Stratigraphy	Lithologic Description	Unified Soil Classification	Recovery, %	PID (ppmv)	Soil Sample ID	Well Configuration	Elevations (ft amsl) and Comments
										Ground Surface 188.2
										Top PVC Casing 191.2
0				no samples recovered						cement surface seal
3–4	1									drilled hole 8.5 inches in diameter
6	2									portland cement with 8% bentonite
8										2 inch diameter well casing
11										bentonite pellets
14	4									20/40 filter sand
16	5	8-Mar-2005								
20	6									2 inch diameter schedule 40 PVC screen (0.010 inch slotted)
23	7									20/40 filter sand
25										bottom screen end cap
28				Borehole depth 28.0 ft (28.0 m)						
29	9									



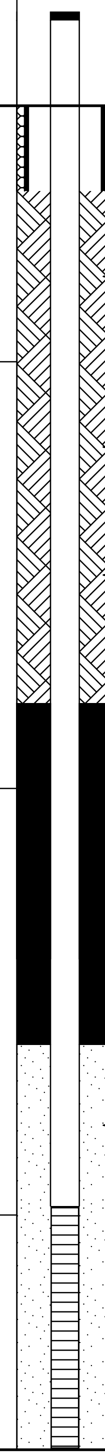
Borehole No. 16EW12B

Borehole Log

Project No.:	TR0136	**Location:**	Site 16 Landfill
Client:	Longhorn Army Ammunition Plant	**Coordinates:**	N 6,953,704.4 E 3,314,001.6
Geologist:	N. Barros	**Drilling Method:**	Hollow Stem Augers
Drilling Company:	ETTL Drilling Services	**Well Material:**	4 inch PVC Vee-Wire Wrap
Completion Date:	8 December 2003	**Borehole Diameter:**	10 inches
		Site Datum:	Site 16 Landfill Benchmark

Depth, feet	Depth, metres	Water Level	Lithologic Description	Unified Soil Classification	Recovery, %	PID (ppmv)	Soil Sample ID
0 – 3			no samples recovered				
3 – 8	1, 2		sandy silt, trace clay, fine to medium grained, compact, light brown-red, dry to moist, oxidized some clay, fine grained, light brown-grey	SM	100	NA	SS-1
8 – 8.75			silty sand, trace clay, loose, brown, dry to moist	SM			
8.75 – 11.6	3		sandy clay, some silt, stiff, brown-grey, moist to wet higher clay content (10'2" - 10'6")	CL	100	NA	SS-2
11.6 – 13			silty sand, some clay, medium to coarse grained, loose, light brown-grey, moist to wet higher clay content (12'5" - 12'8") sample taken (12'10" - 13')	SM			
13 – 16	4	▼ 8-Mar-2005	very loose, light brown, wet sample taken (13'10" - 15'1") some clay, compact, light brown-grey, moist to wet	SM	83	NA	SS-3

Well Configuration



Elevations (ft amsl) and Comments

Ground Surface

Top PVC Casing

- cement surface seal
- drilled hole 10 inches in diameter
- 4 inch diameter well casing
- portland cement with 8% bentonite
- bentonite pellets (1/2 inch)
- 12/20 filter sand

Project No.: TR0136
Client: Longhorn Army Ammunition Plant
Geologist: N. Barros
Drilling Company: ETTL Drilling Services
Completion Date: 8 December 2003

Location: Site 16 Landfill
Coordinates: N 6,953,704.4 E 3,314,001.6
Drilling Method: Hollow Stem Augers
Well Material: 4 inch PVC Vee-Wire Wrap
Borehole Diameter: 10 inches
Site Datum: Site 16 Landfill Benchmark

Depth, feet	Depth, metres	Water Level	Stratigraphy	Lithologic Description	Unified Soil Classification	Recovery, %	PID (ppmv)	Soil Sample ID	Well Configuration	Elevations (ft amsl) and Comments (Ground Surface / Top PVC Casing)
16	5			higher clay content (15'11" - 16'3")	SM					
17				silty clay, some sand, stiff, light brown-grey, moist; higher clay content, very stiff (16'10" - 17'9")	CLMS					
18				sandy clay, moist to wet (18'5" - 19'2")						
19	6			silty clay, some sand, very stiff, light brown, red-brown, some grey, moist	CL	100	NA	SS-4		
20										4 inch diameter PVC Vee-Wire Wrap Screen (0.010 inch slotted)
21										
22				silty sand, some clay, medium grained, loose, brown-grey, moist	SM					
23	7			compact, moist to wet; wet (23' - 23'7")						
24				some clay (23'9" - 24'2")						
25						88	NA	SS-5		12/20 filter sand
26	8									
27				sample taken (27'1.5" - 27'5")						bottom screen; end cap
28				no samples recovered						
29	9									formation collapse
30				Borehole depth 30.0 ft (30.0 m)						
31										

Borehole No. 16EW13

Borehole Log

Project No.:	TR0136	**Location:**	Site 16 Landfill
Client:	Longhorn Army Ammunition Plant	**Coordinates:**	N 6,953,670.3 E 3,314,000.2
Geologist:	N. Barros	**Drilling Method:**	Hollow Stem Augers
		Well Material:	4 inch PVC Vee-Wire Wrap
Drilling Company:	ETTL Drilling Services	**Borehole Diameter:**	10 inches
Completion Date:	24 June 2003	**Site Datum:**	Site 16 Landfill Benchmark

Elevations (ft amsl) and Comments: Ground Surface 186.6; Top PVC Casing 189.9

Depth, feet	Depth, metres	Water Level	Stratigraphy	Lithologic Description	Unified Soil Classification	Recovery, %	PID (ppmv)	Soil Sample ID	Well Configuration	Elevations (ft amsl) and Comments
0–3				no samples recovered						cement surface seal (0–1); drilled hole 10 inches in diameter
3–4.8	1			clayey silt, trace sand, fine to medium, stff, mottled brown, grey and red, moist, roots	MLCS	60	NA	SS-1		
4.8–5.5				silty sand, medium, very loose, brown and grey, moist to wet	SM					
5.5–8.2	2			silty clay, some sand, trace gravel, stiff, mottled brown, grey and red, moist	CL MLSG					portland cement with 8% bentonite; 4 inch diameter well casing
8.2–10.6	3			clayey sand, some silt, loose, mottled brown, grey and red, moist, some clay lenses	SC SM	100	NA	SS-2		
10.6–11.3				clayey silt, mottled brown, grey and red, moist	MLC					
11.3–14.5	4			silty sand, medium to coarse, loose, brown, moist to wet silty clay lens (12') silty clay lens (12'10" - 13') grey, some roots clay lens (13'8" - 13'10")	SM					bentonite pellets (11–13); 20/40 filter sand (13–)

GEOSYNTEC CONSULTANTS

Borehole No. 16EW13

Borehole Log

Project No.: TR0136
Client: Longhorn Army Ammunition Plant
Geologist: N. Barros
Drilling Company: ETTL Drilling Services
Completion Date: 24 June 2003

Location: Site 16 Landfill
Coordinates: N 6,953,670.3 E 3,314,000.2
Drilling Method: Hollow Stem Augers
Well Material: 4 inch PVC Vee-Wire Wrap
Borehole Diameter: 10 inches
Site Datum: Site 16 Landfill Benchmark

Elevations (ft amsl) and Comments: Ground Surface 186.6; Top PVC Casing 189.9

Water Level: 8-Mar-2005 (approx. 14.5 ft)

Depth, feet	Lithologic Description	Unified Soil Classification	Recovery, %	PID (ppmv)	Soil Sample ID
14.5		SM			
14.75	clayey silt, some sand, medium, firm, mottled brown grey red, moist; silty sand (15'8" - 16')	MLCS	95	NA	SS-3
16	silty clay, some sand, fine to medium, stiff, mottled brown, grey and red, moist	CL MLS			
16.75	clay, some silt, fine, very stiff, brown and grey, moist	CLM			
17.4	sitly clay, fine to medium (17'5" - 17'9"); sandy silt, some clay, fine to medium, loose mottled brown grey, wet	MLS			
18.7	silty clay, some sand, fine to medium, very stiff, mottled brown grey, moist; sandy clay (21'6" - 21'10")	CLM	82	NA	SS-4
21.8	silty sand, trace clay, medium to coarse, very loose, mottled brown grey red, wet, roots; green tint	SM	78	NA	SS-5
28	Borehole depth 28.0 ft (28.0 m)				

Well Configuration comments:
- 4 inch diameter schedule 40 PVC screen (0.010 inch slotted)
- 20/40 filter sand
- bottom screen
- end cap
- Slough

Borehole No. 16EW14

Borehole Log

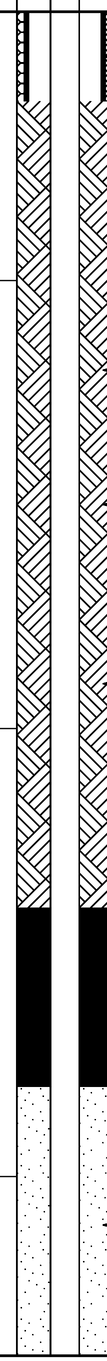
Project No.: TR0136
Client: Longhorn Army Ammunition Plant
Geologist: D. Bertrand
Drilling Company: ETTL Drilling Services
Completion Date: 24 June 2003

Location: Site 16 Landfill
Coordinates: N 6,953,634.2 E 3,313,994.3
Drilling Method: Hollow Stem Augers
Well Material: 4 inch PVC Vee-Wire Wrap
Borehole Diameter: 10 inches
Site Datum: Site 16 Landfill Benchmark

Elevations (ft amsl) and Comments: Ground Surface 186.8; Top PVC Casing 189.8

Depth, feet	Depth, metres	Lithologic Description	Unified Soil Classification	Recovery, %	PID (ppmv)	Soil Sample ID
0–3		no samples recovered				
3–8.5	1, 2	silt, some clay, firm, dark brown, moist to wet, lots of roots causing poor recovery	MLC	72	NA	SS-1
8.5–9.4		silty clay, stiff, mottled brown and grey	CLM	37	NA	SS-2
9.4–13	3	sand, some clay, fine to medium, loose, brown, moist	SC			
13–	4	silty sand, fine to medium, well sorted, very loose, brown and grey, very wet causing poor recovery some clay	SM			

Water Level: 8-Mar-2005 (at approx. 14.5 ft)



Borehole No. 16EW14

Borehole Log

Project No.:	TR0136	**Location:**	Site 16 Landfill
Client:	Longhorn Army Ammunition Plant	**Coordinates:**	N 6,953,634.2 E 3,313,994.3
Geologist:	D. Bertrand	**Drilling Method:**	Hollow Stem Augers
		Well Material:	4 inch PVC Vee-Wire Wrap
Drilling Company:	ETTL Drilling Services	**Borehole Diameter:**	10 inches
Completion Date:	24 June 2003	**Site Datum:**	Site 16 Landfill Benchmark

Depth, feet	Depth, metres	Water Level	Stratigraphy	Lithologic Description	Unified Soil Classification	Recovery, %	PID (ppmv)	Soil Sample ID	Well Configuration	Elevations (ft amsl) and Comments
										Ground Surface 186.8; Top PVC Casing 189.8
15–18	5				SM	27	NA	SS-3		
18–24	6, 7			silty clay, very stiff, light brown, wet	CLM	63	NA	SS-4		4 inch diameter schedule 40 PVC screen (0.010 inch slotted); 20/40 filter sand
24–26				no samples recovered		0	NA	SS-5		bottom screen; end cap
26	8			Borehole depth 26.0 ft (26.0 m)						
27–29	9									

Borehole No. 16EW14B

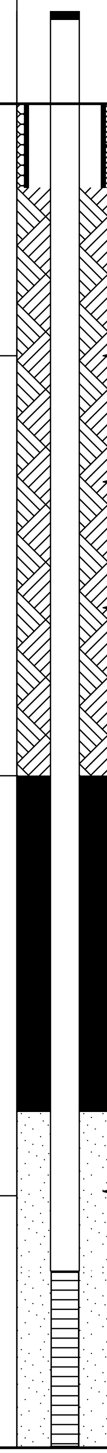
Borehole Log

Project No.: TR0136
Client: Longhorn Army Ammunition Plant
Geologist: N. Barros
Drilling Company: ETTL Drilling Services
Completion Date: 8 December 2003

Location: Site 16 Landfill
Coordinates: N 6,953,633.2 E 3,313,997.3
Drilling Method: Hollow Stem Augers
Well Material: 4 inch PVC Vee-Wire Wrap
Borehole Diameter: 10 inches
Site Datum: Site 16 Landfill Benchmark

Depth, feet	Depth, metres	Water Level	Lithologic Description	Unified Soil Classification	Recovery, %	PID (ppmv)	Soil Sample ID	Elevations (ft amsl) and Comments
								Ground Surface; Top PVC Casing
0–3 (1, 2)			no samples recovered					cement surface seal
3–6 (3, 4, 5, 6)	1		no sample recovered, pushed a root causing poor recovery		40	NA	SS-1	drilled hole 10 inches in diameter; portland cement with 8% bentonite; 4 inch diameter well casing
6–8 (7, 8)	2		silty clay, soft, grey-black, moist	CLM				
8–11 (9, 10, 11)	3		silty sand, some roots, medium grained, very loose, brown-grey, moist to wet	SM	55	NA	SS-2	bentonite pellets (1/2 inch)
11–12 (12)			clay, some silt, very stiff, grey-black mottled, dry to moist	CL				
12–15 (13, 14)	4	8-Mar-2005	clayey sand, medium grained, loose, brown-grey mottled, dry to moist, some roots	SC				12/20 filter sand
15– (15)			clay, some silt, stiff, brown-grey mottled, moist	CL	98	NA	SS-3	

Well Configuration



Borehole No. 16EW14B

Borehole Log

Project No.:	TR0136	**Location:**	Site 16 Landfill
Client:	Longhorn Army Ammunition Plant	**Coordinates:**	N 6,953,633.2 E 3,313,997.3
Geologist:	N. Barros	**Drilling Method:**	Hollow Stem Augers
		Well Material:	4 inch PVC Vee-Wire Wrap
Drilling Company:	ETTL Drilling Services	**Borehole Diameter:**	10 inches
Completion Date:	8 December 2003	**Site Datum:**	Site 16 Landfill Benchmark

Depth, feet	Depth, metres	Water Level	Stratigraphy	Lithologic Description	Unified Soil Classification	Recovery, %	PID (ppmv)	Soil Sample ID	Well Configuration	Elevations (ft amsl) and Comments (Ground Surface / Top PVC Casing)
16.6–17	5				CL					
17–18				sandy clay, firm, brown-grey mottled, moist to wet	CLS					
18–21.3	6			clay, trace silt, stiff, brown-grey mottled, dry to moist, some roots	CL	100	NA	SS-4		4 inch diameter PVC Vee-Wire Wrap Screen (0.010 inch slotted)
21.3–22.8				clayey sand, some roots, compact, brown-grey, moist	SC					
22.8–28	7, 8			silty sand, medium to coarse grained, loose, brown-grey, wet causing poor recovery	SM	50	NA	SS-5		12/20 filter sand
28–30	9			no samples recovered						bottom screen; end cap; formation collapse
30				Borehole depth 30.0 ft (30.0 m)						

GEOSYNTEC CONSULTANTS

Borehole No. 16EW15

Borehole Log

Project No.:	TR0136	**Location:**	Site 16 Landfill
Client:	Longhorn Army Ammunition Plant	**Coordinates:**	N 6,953,600.9 E 3,313,989.6
Geologist:	D. Bertrand	**Drilling Method:**	Hollow Stem Augers
Drilling Company:	ETTL Drilling Services	**Well Material:**	4 inch PVC Vee-Wire Wrap
Completion Date:	23 June 2003	**Borehole Diameter:**	10 inches
		Site Datum:	Site 16 Landfill Benchmark

Depth, feet	Depth, metres	Water Level	Stratigraphy	Lithologic Description	Unified Soil Classification	Recovery, %	PID (ppmv)	Soil Sample ID
0–3				no samples recovered				
3–7.6	1, 2			silty clay, very stiff, mottled brown grey, moist some sand (6'3")	CLM	100	NA	SS-1
7.6–9.8	3			silty sand, fine to medium, loose, brown, moist some grey mottling, moist trace clay (8'6" - 9'9")	SM SM	97	NA	SS-2
9.8–11.6				silt, trace clay, fine, firm, brown, moist to wet some sand	ML			
11.6–13	4			sand, trace clay, fine to medium, loose, brown, moist to wet, some grey clay pockets	SC			
13–15		▼ 8-Mar-2005		silty sand, fine to medium, loose, brown, wet mottled grey and brown (14'8")	SM			

Well Configuration

Elevations (ft amsl) and Comments	
Ground Surface	186.8
Top PVC Casing	189.8

- cement surface seal
- drilled hole 10 inches in diameter
- portland cement with 8% bentonite
- 4 inch diameter well casing
- bentonite pellets
- 20/40 filter sand

Borehole No. 16EW15

Borehole Log

Project No.: TR0136
Client: Longhorn Army Ammunition Plant
Geologist: D. Bertrand
Drilling Company: ETTL Drilling Services
Completion Date: 23 June 2003

Location: Site 16 Landfill
Coordinates: N 6,953,600.9 E 3,313,989.6
Drilling Method: Hollow Stem Augers
Well Material: 4 inch PVC Vee-Wire Wrap
Borehole Diameter: 10 inches
Site Datum: Site 16 Landfill Benchmark

Elevations (ft amsl) and Comments: Ground Surface 186.8; Top PVC Casing 189.8

Depth, feet	Depth, metres	Water Level	Stratigraphy	Lithologic Description	Unified Soil Classification	Recovery, %	PID (ppmv)	Soil Sample ID	Well Configuration	Elevations (ft amsl) and Comments
15.1–16.0				sandy silt, fine, loose, mottled brown grey, moist to wet	MLS	100	NA	SS-3		
16.0–18.0	5			silty clay, very stiff, mottled brown and grey, moist to wet	CLM					
18.0–18.5				silty sand, trace clay, fine, loose, mottled brown grey, moist to wet	SM	100	NA	SS-4		4 inch diameter schedule 40 PVC screen (0.010 inch slotted)
18.5–21.0	6			silty clay, very stiff, mottled brown grey, moist to wet	CLM					
21.0–22.0				silty sand, loose, brown, wet, small pockets of grey	SM					20/40 filter sand
22.0–23.0	7			sandy silt, trace clay, brown grey, wet, small pockets of grey	MLS					
23.0–24.0				silty sand, some clay, loose, brown, wet	SPMC	100	NA	SS-5		bottom screen; end cap
24.0–28.0	8			silty clay, fine, v. stiff, mottled brown grey, moist	CLM					slough
28.0				Borehole depth 28.0 ft (28.0 m)						
29	9									

GeoSyntec Consultants

Borehole No. 16IW01

Borehole Log

Project No.: TR0136

Client: Longhorn Army Ammunition Plant

Geologist: B. Corrigan

Drilling Company: ETTL Drilling Services

Completion Date: 2 September 2003

Location: Site 16 Landfill

Coordinates:

Drilling Method: Hollow Stem Augers

Well Material: 4 inch PVC Vee-Wire Wrap

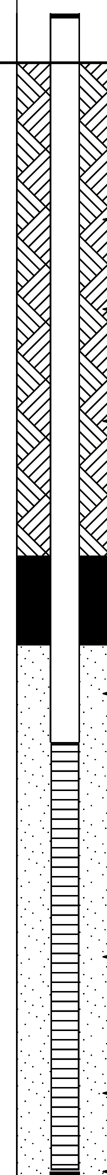
Borehole Diameter: 8 inches

Site Datum: Site 16 Landfill Benchmark

Depth		Water Level	Stratigraphy	Lithologic Description	Geologic Samples				Well Configuration	Elevations (ft amsl) and Comments
Depth, feet	Depth, metres				Unified Soil Classification	Recovery, %	PID (ppmv)	Soil Sample ID		Ground Surface Top PVC Casing

Depth, feet: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29

Depth, metres: 1, 2, 3, 4, 5, 6, 7, 8, 9



drilled hole 8 inches in diameter

portland cement with 8% bentonite

2 inch diameter well casing

bentonite pellets

20/40 filter sand

2 inch diameter schedule 40 PVC screen (0.010 inch slotted)

20/40 filter sand

bottom screen

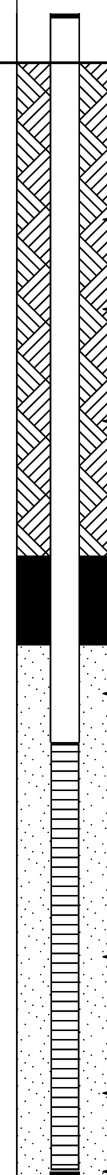
end cap

Borehole No. 16IW02

Borehole Log

Project No.:	TR0136	**Location:**	Site 16 Landfill
Client:	Longhorn Army Ammunition Plant	**Coordinates:**	
Geologist:	B. Corrigan	**Drilling Method:**	Hollow Stem Augers
		Well Material:	4 inch PVC Vee-Wire Wrap
Drilling Company:	ETTL Drilling Services	**Borehole Diameter:**	8 inches
Completion Date:	2 September 2003	**Site Datum:**	Site 16 Landfill Benchmark

Depth, feet	Depth, metres	Water Level	Stratigraphy	Lithologic Description	Unified Soil Classification	Recovery, %	PID (ppmv)	Soil Sample ID	Well Configuration	Elevations (ft amsl) and Comments
										Ground Surface
										Top PVC Casing
1										
2										
3	1									
4										drilled hole 8 inches in diameter
5										
6	2									portland cement with 8% bentonite
7										
8										2 inch diameter well casing
9										
10	3									
11										
12										bentonite pellets
13	4									
14										20/40 filter sand
15										
16	5									
17										
18										
19										
20	6									2 inch diameter schedule 40 PVC screen (0.010 inch slotted)
21										
22										
23	7									20/40 filter sand
24										
25										bottom screen end cap
26	8									
27										
28										
29	9									



GEOSYNTEC CONSULTANTS

Borehole No. 16IW03

Borehole Log

Project No.: TR0136

Client: Longhorn Army Ammunition Plant

Geologist: B. Corrigan

Drilling Company: ETTL Drilling Services

Completion Date: 2 September 2003

Location: Site 16 Landfill

Coordinates:

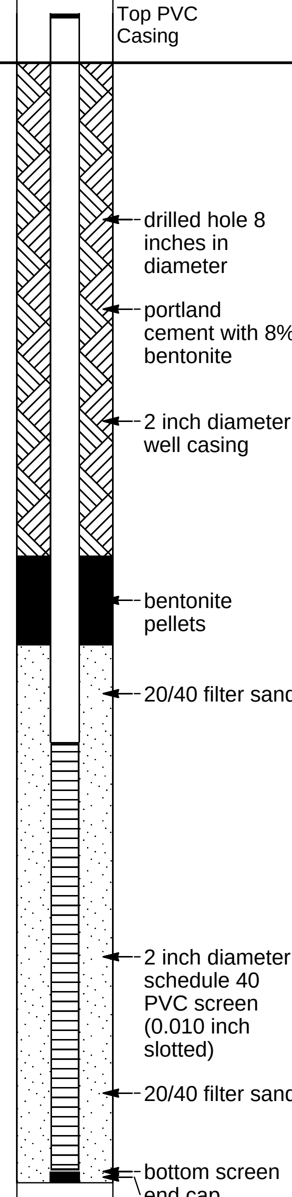
Drilling Method: Hollow Stem Augers

Well Material: 4 inch PVC Vee-Wire Wrap

Borehole Diameter: 8 inches

Site Datum: Site 16 Landfill Benchmark

Depth, feet	Depth, metres	Water Level	Stratigraphy	Lithologic Description	Unified Soil Classification	Recovery, %	PID (ppmv)	Soil Sample ID	Well Configuration	Elevations (ft amsl) and Comments
										Ground Surface Top PVC Casing
1–29	1–9									



Borehole No. 16IW04

Borehole Log

Project No.:	TR0136	**Location:**	Site 16 Landfill
Client:	Longhorn Army Ammunition Plant	**Coordinates:**	
Geologist:	B. Corrigan	**Drilling Method:**	Hollow Stem Augers
		Well Material:	4 inch PVC Vee-Wire Wrap
Drilling Company:	ETTL Drilling Services	**Borehole Diameter:**	8 inches
Completion Date:	3 September 2003	**Site Datum:**	Site 16 Landfill Benchmark

Depth, feet	Depth, metres	Water Level	Stratigraphy	Lithologic Description	Unified Soil Classification	Recovery, %	PID (ppmv)	Soil Sample ID	Well Configuration	Elevations (ft amsl) and Comments
										Ground Surface
										Top PVC Casing
1										
2										
3	1									
4										drilled hole 8 inches in diameter
5										
6										portland cement with 8% bentonite
7	2									
8										2 inch diameter well casing
9										
10	3									
11										
12										bentonite pellets
13	4									
14										20/40 filter sand
15										
16	5									
17										
18										
19										
20	6									2 inch diameter schedule 40 PVC screen (0.010 inch slotted)
21										
22										
23	7									20/40 filter sand
24										
25										bottom screen end cap
26	8									
27										
28										
29	9									

Borehole No. 16IW05

Borehole Log

Project No.: TR0136

Client: Longhorn Army Ammunition Plant

Geologist: B. Corrigan

Drilling Company: ETTL Drilling Services

Completion Date: 2 September 2003

Location: Site 16 Landfill

Coordinates:

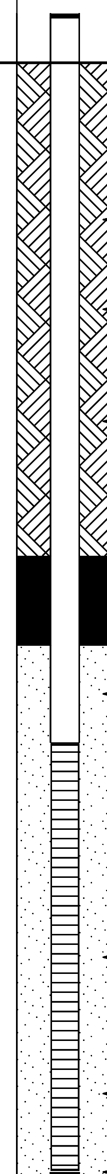
Drilling Method: Hollow Stem Augers

Well Material: 4 inch PVC Vee-Wire Wrap

Borehole Diameter: 8 inches

Site Datum: Site 16 Landfill Benchmark

Depth, feet	Depth, metres	Water Level	Stratigraphy	Lithologic Description	Unified Soil Classification	Recovery, %	PID (ppmv)	Soil Sample ID	Well Configuration	Elevations (ft amsl) and Comments
										Ground Surface
										Top PVC Casing
1										
2										
3	1									
4										drilled hole 8 inches in diameter
5										
6										portland cement with 8% bentonite
7	2									
8										2 inch diameter well casing
9										
10	3									
11										
12										bentonite pellets
13	4									
14										20/40 filter sand
15										
16	5									
17										
18										
19										
20	6									2 inch diameter schedule 40 PVC screen (0.010 inch slotted)
21										
22										
23	7									20/40 filter sand
24										
25										bottom screen end cap
26	8									
27										
28										
29	9									



Borehole No. 16IW06

Borehole Log

Project No.: TR0136

Client: Longhorn Army Ammunition Plant

Geologist: B. Corrigan

Drilling Company: ETTL Drilling Services

Completion Date: 2 September 2003

Location: Site 16 Landfill

Coordinates:

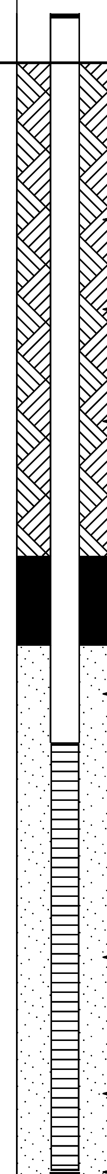
Drilling Method: Hollow Stem Augers

Well Material: 4 inch PVC Vee-Wire Wrap

Borehole Diameter: 8 inches

Site Datum: Site 16 Landfill Benchmark

Depth, feet	Depth, metres	Water Level	Stratigraphy	Lithologic Description	Unified Soil Classification	Recovery, %	PID (ppmv)	Soil Sample ID	Well Configuration	Elevations (ft amsl) and Comments
										Ground Surface
										Top PVC Casing
1										
2										
3	1									
4										drilled hole 8 inches in diameter
5										
6	2									portland cement with 8% bentonite
7										
8										2 inch diameter well casing
9										
10	3									
11										
12										bentonite pellets
13	4									
14										20/40 filter sand
15										
16	5									
17										
18										
19										
20	6									2 inch diameter schedule 40 PVC screen (0.010 inch slotted)
21										
22										
23	7									20/40 filter sand
24										
25										bottom screen end cap
26	8									
27										
28										
29	9									



GEOSYNTEC CONSULTANTS

Borehole No. 16IW07

Borehole Log

Project No.: TR0136

Client: Longhorn Army Ammunition Plant

Geologist: B. Corrigan

Drilling Company: ETTL Drilling Services

Completion Date: 3 September 2003

Location: Site 16 Landfill

Coordinates:

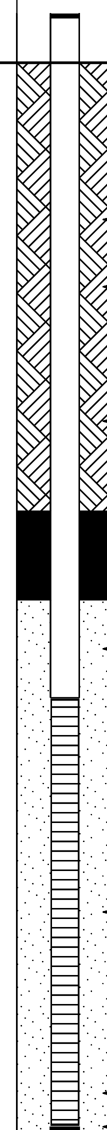
Drilling Method: Hollow Stem Augers

Well Material: 4 inch PVC Vee-Wire Wrap

Borehole Diameter: 8 inches

Site Datum: Site 16 Landfill Benchmark

Depth, feet	Depth, metres	Water Level	Stratigraphy	Lithologic Description	Unified Soil Classification	Recovery, %	PID (ppmv)	Soil Sample ID	Well Configuration	Elevations (ft amsl) and Comments
										Ground Surface Top PVC Casing
1										
2										
3	1									drilled hole 8 inches in diameter
4										
5										portland cement with 8% bentonite
6	2									
7										
8										2 inch diameter well casing
9										
10	3									
11										bentonite pellets
12										
13	4									20/40 filter sand
14										
15										
16	5									
17										
18										
19										2 inch diameter schedule 40 PVC screen (0.010 inch slotted)
20	6									
21										
22										
23	7									20/40 filter sand
24										bottom screen end cap
25										
26	8									
27										
28										
29	9									

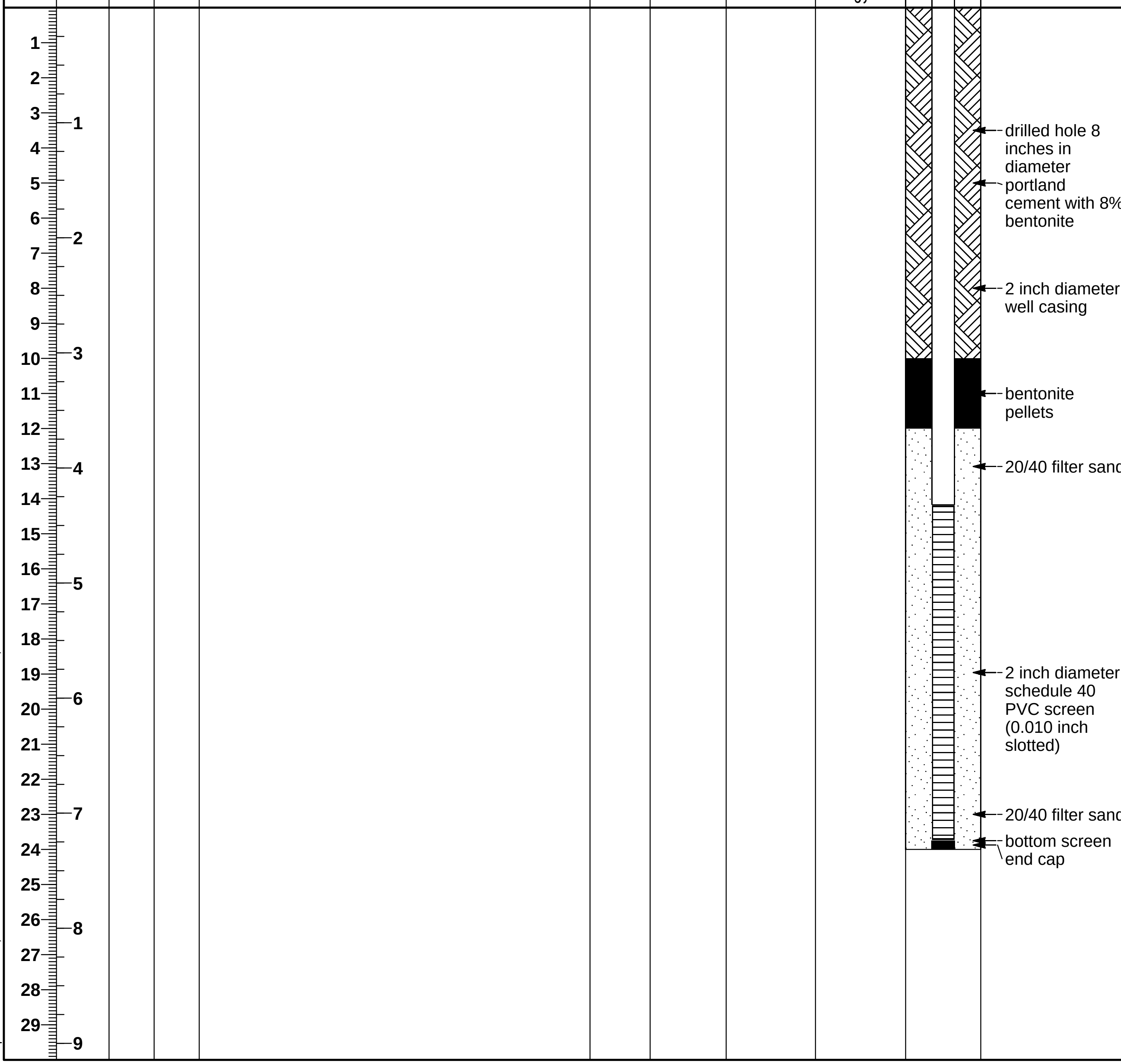


Borehole No. 16IW08

Borehole Log

Project No.:	TR0136	**Location:**	Site 16 Landfill
Client:	Longhorn Army Ammunition Plant	**Coordinates:**	
Geologist:	B. Corrigan	**Drilling Method:**	Hollow Stem Augers
		Well Material:	4 inch PVC Vee-Wire Wrap
Drilling Company:	ETTL Drilling Services	**Borehole Diameter:**	8 inches
Completion Date:	3 September 2003	**Site Datum:**	Site 16 Landfill Benchmark

Depth, feet	Depth, metres	Water Level	Stratigraphy	Lithologic Description	Unified Soil Classification	Recovery, %	PID (ppmv)	Soil Sample ID	Well Configuration	Elevations (ft amsl) and Comments
										Ground Surface
										Top PVC Casing



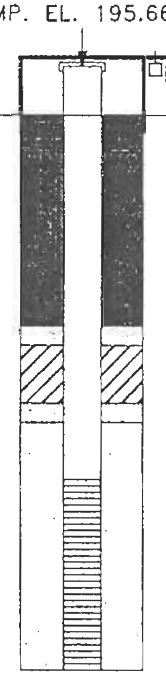
Sverdrup ENVIRONMENTAL	Site ID: 16WW16	Page 1 of 1
	X Coordinate: 3313895.70	Y Coordinate: 6953639.30
Location: Longhorn Army Ammunition Plant	Elevation: 193.04'	Datum: NGVD
e(s): 04/14/95 - 04/14/95	Total Depth: 29.00'	Measuring Point: 195.66'
Logged By: K. Williams	Completed Depth: 29.00'	Static Water Level:
Contractor: Burlington Environmenta Inc.	Well Casing: type: SS dia: 4.00in fm: -2.6' to: 19.00'	
Drilling Method: 6-1/4 in. I.D. Hollow Stem Auger	Screens: type: Slotted size: .010in dia: 4.00in fm: 19.00' to: 29.00'	
Remarks:	Annular Fill:	

Annular Fill type	fm	to
Bentonite/Cement Grout.	.00'	2.00'
Bentonite Grout	2.00'	11.00'
Secondary Sand Filter	11.00'	12.00'
Granular Bentonite Seal	12.00'	15.00'
Secondary Sand Filter	15.00'	16.00'
#20-40 Silica Filter Sand	16.00'	29.00'

Elevation (ft)	Depth (ft)	Sample No.	Blow Count	USCS Code	Material Description
	0	SS-1	WH 1 1 2	ML	clayey SILT- red-brown, medium stiff, low plasticity, moist
190	5	SS-2	5 10 14 17	CL	silty CLAY- gray with red-brown streaks and mottling, stiff, medium plasticity, moist
180	10	SS-3	7 9 12 15		
	15	SS-4	4 5 6 6	SC/CL	sandy CLAY- light brown, medium stiff, low plasticity, moist
170	20	SS-5	2 8 11 13	SW	SAND- light brown, fine grained, trace fines, loose, saturated
	25	SS-6	2 5 6 8	SW/SC	sandy silty CLAY- light brown and gray mottled, interbedded with sand, stiff, medium plasticity, moist to wet
		SS-7	3 9 11	SW SW/SC	SAND- light brown, trace fines, loose, saturated sandy silty CLAY- light brown with gray mottling, stiff, medium plasticity, moist to wet
160	30, 35				
150	40, 45				
140	50, 55				

Well Construction

MP. EL. 195.66



Sverdrup
ENVIRONMENTAL

Site ID: **16WW35**	
X Coordinate: 3314077.77	Y Coordinate: 6953657.15
Location: LONGHORN ARMY AMMUNTION PLANT	
Elevation: 187.42'	Datum: NGVD
Date(s): 06/26/97 – 06/26/97	
Total Depth: 44.00'	Measuring Point: 190.53'
Logged By: Sandra Rudolph	
Completed Depth: 43.50'	Static Water Level:
Contractor: Philip Environmental	
Well Casing: type: SS dia: 4.00in fm: -3.1' to: 33.50'	
Drilling Method: Hollow Stem Auger	
Screens: type: Wire-wrap size: 0.010in dia: 4.00in fm: 33.50' to: 43.50'	
Remarks:	

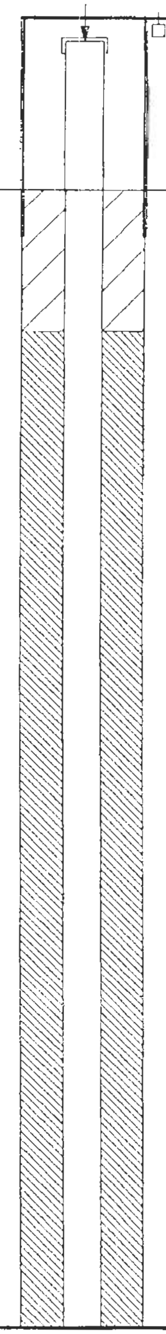
Annular Fill:

type	fm	to
Cement Grout	0.00'	3.00'
Bentonite/Cement Grout	3.00'	25.00'
#20-40 Silica Filter Sand	25.00'	26.00'
Bentonite Pellets	26.00'	29.00'
#20-40 Silica Filter Sand	29.00'	30.00'
Sand Filter	30.00'	44.00'

Elevation (ft)	Depth (ft)	Sample No.	Blow Count	USCS Code	Material Description
				CL	
		SS-1	4 5 6 8		CLAY, silty, with fine sand, reddish-brown and lt. brown, medium stiff, med. plastic, dry to damp
		SS-2	4 17 12 13		
	5	SS-3	4 11 17 22		CLAY, silty, brown with gray mottling, stiff, plastic, dry to damp
180		SS-4	3 7 9 9	ML/CL	SILT to CLAY, silty, with fine grained sand, gray with reddish-brown mottling, med. stiff, med. plastic, damp to moist
		SS-5	3 4 5 6	SM	SAND, silty, fine grained, brown, 9.25 – 9.35 ft.
	10			ML/CL	SILT to CLAY, silty, with fine grained sand, brown with gray mottling, med. stiff, low to med. plastic, damp to moist
		SS-6	4 4 4 5	SM	SAND, silty, brown, fine grained, med. dense, moist
		SS-7	2 4	CL	CLAY, silty, trace fine grained sand, brown with gray and black mottling, med. stiff, med. plastic, damp to moist
		SS-8	2 4 5 5	SM	SAND, silty, fine grained, brown with gray, black, and reddish-brown mottling, med. dense, moist to wet
	15			CL	CLAY, silty, gray with brown mottling, med. stiff, plastic, moist to wet
		SS-9	1 11 24 48	SM	SAND, silty, fine grained, brown, med. dense, wet to saturated
170		SS-10	4 5 3 4		SAND, silty, fine grained, gray, med. dense to loose, wet to saturated
	20	SS-11	2 4 5 7	CL	CLAY, silty, brown and gray, stiff, plastic, damp to moist
				SM	SAND, silty, fine grained, brown with gray mottling, med. dense, wet to saturated
		SS-12	4 5 7 8	CL	CLAY, silty, trace fine grained sand, brown with gray and black mottling, med. stiff, med. plastic, damp to moist
					CLAY, silty, brown with gray mottling, stiff, plastic, dry to damp

Well Construction

MP. EL. 190.53



Site Id: 16WW35 | Date(s): 06/26/97 - 06/26/97

Elevation (ft)	Depth (ft)	Recovery	Sample No.	Blow Count	Graphic Log	USCS Code	Material Description	Well Construction
			SS-13	1 3 3 4		ML	SILT, clayey, with fine grained sand, brown and gray, med. stiff, low plastic, moist to saturated	
160			SS-14	2 3 4 5		CL	CLAY, silty, trace fine grained sand, gray with reddish-brown mottling, med. stiff to stiff, plastic, moist	
	29		SS-15	2		ML	SILT, clayey, with fine grained sand, gray with brown mottling, med. stiff, med. plastic, moist to wet	
			SS-16	1 2 2 4		CL ML/SM	CLAY, silty, grey with brown mottling, stiff, plastic, moist	
			SS-17	2 4 8 17			SILT, clayey and SAND, fine grained, gray with brown mottling, soft, med. plastic, moist to saturated	
							SILT, clayey and SAND, fine grained with angular gravel at 33.6 to 33.8 ft., reddish-brown with gray mottling, wet	
	34		SS-18	1 2 1 1		ML SM/SP	SILT, sandy, fine grained, gray with black mottling, wet	
							SAND, silty, fine grained, gray and brown, loose to med. dense, wet to saturated	
			SS-19	1 2 3 4		SP		
150							SAND, slightly silty, fine grained, gray, loose to med. dense, wet to saturated	
			SS-20	4 8 16 22				
	39						SAND, slightly silty, fine grained, gray with brown mottling, med. dense to dense, wet to saturated	
			SS-21	12 24 46 80				
							SAND, slightly clayey and silty, fine grained, brown and gray, med. dense to dense, wet to saturated	
			SS-22	14 24 23 24				
							SAND, slightly clayey and silty, fine grained, reddish-brown, dense, wet to saturated	
							SAND, slightly silty, fine grained, gray, dense, wet to saturated	
	44					CL/CH	CLAY, silty, with thin layers of lt gray silt, dark gray, very stiff, plastic, dry	
140								
	49							
	54							
0								
	59							

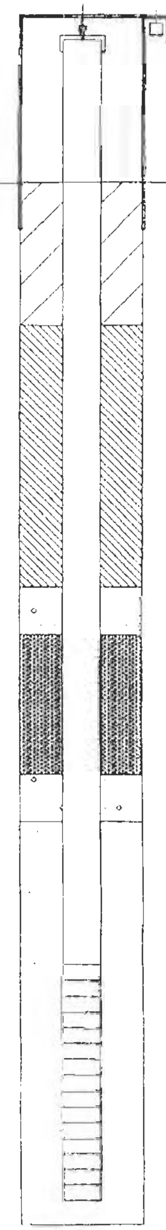
Sverdrup ENVIRONMENTAL	Site ID. 16WW36	
	X Coordinate: 3314085.26	Y Coordinate: 6953660.11
Location: LONGHORN ARMY AMMUNITION PLANT	Elevation: 187.86'	Datum: NGVD
Date(s): 06/27/97 - 06/27/97	Total Depth: 22.00'	Measuring Point: 190.85'
Logged By: Sandra Rudolph	Completed Depth: 21.50'	Static Water Level:
Contractor: Philip Environmental	Well Casing: type: SS dia: 4.00in fm: -3.0' to: 16.50'	
Drilling Method: Hollow Stem Auger	Screens: type: Wire-wrap size. 0.010in dia: 4.00in fm: 16.50' to: 21.50'	
Remarks:	Annular Fill:	

Annular Fill type	fm	to
Cement Grout	0.00'	3.00'
Bentonite/Cement Grout	3.00'	8.50'
#20-40 Silica Filter Sand	8.50'	9.50'
Bentonite Pellets	9.50'	12.50'
#20-40 Silica Filter Sand	12.50'	13.50'
Sand Filter	13.50'	22.00'

Elevation (ft)	Depth (ft)	Sample No	Blow Count	USCS Code	Material Description
				CL	
		SS-1	4 5 6 8		CLAY, silty, with fine sand, reddisn-brown and lt. brown, medium stiff, med. plastic, dry to damp
		SS-2	4 12 12 13		
	5	SS-3	4 11 17 22		CLAY, silty, brown with gray mottling, stiff, plastic, dry to damp
		SS-4	3 7 9 9	ML/CL	
180					SILT to CLAY, silty, with fine grained sand, gray with reddish-brown mottling, med. stiff, med. plastic, damp to moist
		SS-5	3 4 5 6	SM	SAND, silty, fine grained, brown, 9.25 - 9.35 ft.
	10			ML/CL	SILT to CLAY, silty, with fine grained sand, brown with gray mottling, med. stiff, low to med. plastic, damp to moist
		SS-6	4 4 4 5	SM	SAND, silty, brown, fine grained, med. dense, moist
		SS-7	2 4	CL	CLAY, silty, trace fine grained sand, brown with gray and black mottling, med. stiff, med. plastic, damp to moist
				SM	SAND, silty, fine grained, brown with gray, black, and reddish-brown mottling, med. dense, moist to wet
	15	SS-8	2 4 5 5	CL	CLAY, silty, gray with brown mottling, med. stiff, plastic, moist to wet
				SM	SAND, silty, fine grained, brown, med. dense, wet to saturated
		SS-9	1 1 2 4		
170		SS-10	4 5 3 4		SAND, silty, fine grained, gray, med. dense to loose, wet to saturated
				CL	CLAY, silty, brown and gray, stiff, plastic, damp to moist
	20	SS-11	2 4 5 7	SM	SAND, silty, fine grained, brown with gray mottling, med. dense, wet to saturated
				CL	CLAY, silty, trace fine grained sand, brown with grey and black mottling, med. stiff, med. plastic, damp to moist
		SS-12	4 5 7 8		

Well Construction

MP. EL. 190.85



APPENDIX D

DESCRIPTION OF NUMERICAL MODEL

APPENDIX D
DESCRIPTION OF NUMERICAL MODEL

D.1 INTRODUCTION

This appendix presents a numerical groundwater flow model that was developed to assist in design and operation of the semi-passive bioremediation system for in situ treatment perchlorate impacted groundwater at the Longhorn Army Ammunition Plan (LHAAP) in Karnack, Texas.

D.2 MODELING OBJECTIVES

The objectives of this numerical model are to evaluate the design of the semi-passive electron donor addition system to optimize the design and operation of the bioremediation system at LHAAP.

D.3 MODEL DESCRIPTION

D.3.1 Numerical Codes, Assumptions and Limitations

Groundwater flow and particle tracking were simulated using MODFLOW and MODPATH, which are both industry standard modeling codes developed by the United States Geological Survey. The chosen software implementation (i.e., graphical user interface) of these codes was VisualMODFLOW™, developed and marketed by Waterloo Hydrogeologic Software, Ltd.

The model constructed for the site simulates saturated, steady-state conditions with uniform density and temperature, and homogenous anisotropic hydraulic properties within a single model layer, representing the overburden in the Site Area.

D.3.2 Solution Techniques

The groundwater flow equation was solved using the Waterloo Hydrogeologic Matrix solver method with a residual convergence criterion of 0.01 ft and a head change criterion of 0.01 ft.

D.3.3 Domain and Boundaries

The model domain encompasses the Demonstration Test Area (DTA) with model boundaries located far enough from the area of interest to avoid significant boundary effects. It is important to note that the model is not intended to simulate observed conditions throughout the entire domain but only in close proximity to the DTA.

The model domain is oriented to the azimuth and encompasses 2,000 feet in the east-west direction and 1,000 feet in the north-south direction for a total area of 2,000,000 ft^2. Since only the middle 350 feet along the east-west direction of the model are active, the effective simulation area is 350,000 ft^2. Constant head values were assigned linearly (in a north-south direction at the eastern and western boundary of the active area of the model) with values of 185.5 ft to the east and 164.5 ft to the west such that ambient groundwater flow was simulated in an easterly direction at a gradient of 0.057 ft/ft and the ambient groundwater elevation at the DTA was about 174.5 ft above mean sea level (amsl). The model has 200 rows (ranging from easting 3,313,000 ft to 3,315,000 ft), 160 columns (ranging from northing 6,853,000 ft to 6,854,000 ft) and eleven active layers (ranging from 160 ft amsl to 190 ft amsl). The cell size was variable, with smaller cells in the vicinity of the DTA.

The entire model was assigned the following property values:

Property	**Value**	**Units**
Horizontal Hydraulic Conductivity	2	ft/day
Vertical Hydraulic Conductivity	0.02	ft/day
Effective Porosity	0.3	-
Specific Yield	0.1	-
Specific Storage	0.0001	ft^{-1}

D.4 MODEL SIMULATIONS

The model simulations presented in the text represent the results of steady-state simulations. Particle tracks were generated from backward tracking particles released at extraction wells, and forward-tracking particle tracks released at injection wells. Particle track arrowheads represent 1 week travel time increments.

APPENDIX E

WATER LEVEL DATA AND ANALYSIS

TABLE E-1: GROUNDWATER ELEVATION DATA.
Site 16 Landfill, LHAAP, Karnack, Texas

Location	Date Sampled	Depth to Groundwater (ft bgs)	Groundwater Elevation (ft msl)	Location	Date Sampled	Depth to Groundwater (ft bgs)	Groundwater Elevation (ft msl)
16EW01	8-Dec-03	27.65	169.73	16PM06	7-Jul-04	14.82	174.75
16EW01	10-Dec-03	27.75	169.63	16PM06	3-Aug-04	14.93	174.64
16EW01	12-Dec-03	27.73	169.65	16PM06	28-Sep-04	15.75	173.82
16EW01	11-Feb-04	27.61	169.77	16PM06	30-Nov-04	15.6	173.97
16EW01	12-Feb-04	27.61	169.77	16PM06	25-Jan-05	14.7	174.87
16EW01	12-Feb-04	28.02	169.36	16PM06	8-Mar-05	14.49	175.08
16EW02	8-Dec-03	24.46	170.5	16PM06	24-May-05	14.52	175.05
16EW02	10-Dec-03	25.67	169.29	16PM06	18-Oct-05	16.2	173.37
16EW02	12-Dec-03	25.52	169.44	16PM06	1-Nov-05	16.32	173.25
16EW02	11-Feb-04	25.38	169.58	16PM06	19-Dec-05	16.52	173.05
16EW02	12-Feb-04	25.38	169.58	16PM06	30-Jan-06	16.64	172.93
16EW02	12-Feb-04	24.35	170.61	16PM06	14-Mar-06	16.61	172.96
16EW05	8-Dec-03	26.77	169.92	16PM06	8-May-06	16.21	173.36
16EW05	10-Dec-03	26.55	170.14	16PM06	20-Jun-06	16.68	172.89
16EW05	12-Dec-03	26.72	169.97	16PM07-D	1-Jul-03	15.22	175.19
16EW05	11-Feb-04	26.71	169.98	16PM07-D	2-Jul-03	15.22	175.19
16EW05	12-Feb-04	26.71	169.98	16PM07-D	8-Dec-03	16.61	173.8
16EW05	12-Feb-04	26.39	170.3	16PM07-D	8-Dec-03	16.54	173.87
16EW06	8-Dec-03	25.18	169.47	16PM07-D	8-Dec-03	16.56	173.85
16EW06	11-Feb-04	24.94	169.71	16PM07-D	9-Dec-03	16.27	174.14
16EW06	12-Feb-04	24.99	169.66	16PM07-D	9-Dec-03	16.57	173.84
16EW06	12-Feb-04	25.18	169.47	16PM07-D	10-Dec-03	16.57	173.84
16EW09	1-Jul-03	15.1	175.27	16PM07-D	10-Dec-03	16.39	174.02
16EW09	2-Jul-03	15.1	175.27	16PM07-D	11-Dec-03	16.61	173.8
16EW09	8-Dec-03	16.49	173.88	16PM07-D	12-Dec-03	16.61	173.8
16EW09	8-Dec-03	16.45	173.92	16PM07-D	12-Dec-03	16.63	173.78
16EW09	8-Dec-03	16.49	173.88	16PM07-D	9-Feb-04	16.78	173.63
16EW09	9-Dec-03	16.16	174.21	16PM07-D	23-Feb-04	16.75	173.66
16EW09	9-Dec-03	16.49	173.88	16PM07-D	25-Feb-04	16.7	173.71
16EW09	10-Dec-03	16.47	173.9	16PM07-D	27-Feb-04	16.8	173.61
16EW09	10-Dec-03	16.46	173.91	16PM07-D	4-May-04	15.97	174.44
16EW09	11-Dec-03	16.52	173.85	16PM07-D	19-May-04	16.05	174.36
16EW09	12-Dec-03	16.51	173.86	16PM07-D	3-Jun-04	16.12	174.29
16EW09	12-Dec-03	16.53	173.84	16PM07-D	14-Jun-04	15.95	174.46
16EW09	9-Feb-04	16.64	173.73	16PM07-D	7-Jul-04	15.7	174.71
16EW09	12-Feb-04	16.69	173.68	16PM07-D	3-Aug-04	15.86	174.55
16EW09	12-Feb-04	16.71	173.66	16PM07-D	28-Sep-04	16.53	173.88
16EW09	12-Feb-04	16.69	173.68	16PM07-D	30-Nov-04	16.38	174.03
16EW09	13-Feb-04	16.63	173.74	16PM07-D	25-Jan-05	15.5	174.91
16EW09	13-Feb-04	16.685	173.69	16PM07-D	8-Mar-05	15.24	175.17
16EW09	13-Feb-04	16.63	173.74	16PM07-D	24-May-05	15.34	175.07
16EW09	14-Feb-04	16.58	173.79	16PM07-D	18-Oct-05	16.98	173.43
16EW09	14-Feb-04	16.57	173.8	16PM07-D	1-Nov-05	17.09	173.32
16EW09	14-Feb-04	16.58	173.79	16PM07-D	19-Dec-05	17.3	173.11
16EW09	15-Feb-04	16.62	173.75	16PM07-D	30-Jan-06	17.41	173
16EW09	15-Feb-04	16.66	173.71	16PM07-D	14-Mar-06	17.4	173.01
16EW09	15-Feb-04	16.62	173.75	16PM07-D	8-May-06	17.13	173.28
16EW09	16-Feb-04	16.62	173.75	16PM07-D	22-Jun-06	17.5	172.91

TABLE E-1: GROUNDWATER ELEVATION DATA.
Site 16 Landfill, LHAAP, Karnack, Texas

Location	Date Sampled	Depth to Groundwater (ft bgs)	Groundwater Elevation (ft msl)	Location	Date Sampled	Depth to Groundwater (ft bgs)	Groundwater Elevation (ft msl)
16EW09	16-Feb-04	16.66	173.71	16PM07-S	1-Jul-03	15.23	175.16
16EW09	16-Feb-04	16.62	173.75	16PM07-S	2-Jul-03	15.22	175.17
16EW09	17-Feb-04	16.61	173.76	16PM07-S	8-Dec-03	16.64	173.75
16EW09	17-Feb-04	16.645	173.73	16PM07-S	8-Dec-03	16.68	173.71
16EW09	17-Feb-04	16.61	173.76	16PM07-S	8-Dec-03	16.62	173.77
16EW09	18-Feb-04	16.61	173.76	16PM07-S	9-Dec-03	16.28	174.11
16EW09	19-Feb-04	16.49	173.88	16PM07-S	9-Dec-03	16.59	173.8
16EW09	20-Feb-04	16.5	173.87	16PM07-S	10-Dec-03	16.52	173.87
16EW09	22-Feb-04	16.57	173.8	16PM07-S	10-Dec-03	16.53	173.86
16EW09	23-Feb-04	16.48	173.89	16PM07-S	11-Dec-03	16.62	173.77
16EW09	25-Feb-04	16.5	173.87	16PM07-S	12-Dec-03	16.61	173.78
16EW09	27-Feb-04	16.55	173.82	16PM07-S	12-Dec-03	16.62	173.77
16EW09	5-Mar-04	16.3	174.07	16PM07-S	9-Feb-04	16.81	173.58
16EW09	9-Mar-04	16.22	174.15	16PM07-S	23-Feb-04	16.86	173.53
16EW09	17-Mar-04	16.12	174.25	16PM07-S	25-Feb-04	16.8	173.59
16EW09	22-Mar-04	16.11	174.26	16PM07-S	27-Feb-04	16.85	173.54
16EW09	24-Mar-04	16.09	174.28	16PM07-S	4-May-04	16.3	174.09
16EW09	20-Apr-04	15.96	174.41	16PM07-S	19-May-04	16.3	174.09
16EW09	5-May-04	16.25	174.12	16PM07-S	3-Jun-04	16.35	174.04
16EW09	18-May-04	15.9	174.47	16PM07-S	14-Jun-04	16.25	174.14
16EW09	2-Jun-04	15.96	174.41	16PM07-S	7-Jul-04	15.95	174.44
16EW09	14-Jun-04	15.8	174.57	16PM07-S	3-Aug-04	16.05	174.34
16EW09	3-Aug-04	15.65	174.72	16PM07-S	28-Sep-04	16.55	173.84
16EW09	28-Sep-04	16.45	173.92	16PM07-S	30-Nov-04	16.4	173.99
16EW09	30-Nov-04	16.3	174.07	16PM07-S	25-Jan-05	15.9	174.49
16EW09	25-Jan-05	15.45	174.92	16PM07-S	8-Mar-05	15.41	174.98
16EW09	8-Mar-05		175.16	16PM07-S	24-May-05	15.36	175.03
16EW09	24-May-05	15.27	175.1	16PM07-S	18-Oct-05	17.04	173.35
16EW09	18-Oct-05	16.95	173.42	16PM07-S	1-Nov-05	17.18	173.21
16EW09	1-Nov-05	17.08	173.29	16PM07-S	19-Dec-05	17.34	173.05
16EW09	19-Dec-05	17.28	173.09	16PM07-S	30-Jan-06	17.44	172.95
16EW09	30-Jan-06	17.32	173.05	16PM07-S	14-Mar-06	17.44	172.95
16EW09	15-Mar-06	17.25	173.12	16PM07-S	8-May-06	17.08	173.31
16EW09	8-May-06	16.9	173.47	16PM07-S	22-Jun-06	17.55	172.84
16EW09	22-Jun-06	17.37	173	16PM08	1-Jul-03	15.81	175.15
16EW10	1-Jul-03	15.06	175.42	16PM08	2-Jul-03	15.805	175.16
16EW10	2-Jul-03	15.05	175.43	16PM08	8-Dec-03	17.22	173.74
16EW10	8-Dec-03	16.47	174.01	16PM08	8-Dec-03	17.21	173.75
16EW10	8-Dec-03	16.42	174.06	16PM08	8-Dec-03	17.19	173.77
16EW10	8-Dec-03	16.43	174.05	16PM08	9-Dec-03	16.97	173.99
16EW10	9-Dec-03	16.12	174.36	16PM08	9-Dec-03	17.21	173.75
16EW10	9-Dec-03	16.46	174.02	16PM08	10-Dec-03	17.15	173.81
16EW10	10-Dec-03	16.46	174.02	16PM08	10-Dec-03	17.18	173.78
16EW10	10-Dec-03	16.4	174.08	16PM08	11-Dec-03	17.23	173.73
16EW10	11-Dec-03	16.48	174	16PM08	12-Dec-03	17.23	173.73
16EW10	12-Dec-03	16.495	173.99	16PM08	9-Feb-04	16.37	174.59
16EW10	9-Feb-04	16.63	173.85	16PM08	12-Feb-04	17.47	173.49
16EW10	12-Feb-04	16.76	173.72	16PM08	13-Feb-04	17.44	173.52

TABLE E-1: GROUNDWATER ELEVATION DATA.
Site 16 Landfill, LHAAP, Karnack, Texas

Location	Date Sampled	Depth to Groundwater (ft bgs)	Groundwater Elevation (ft msl)	Location	Date Sampled	Depth to Groundwater (ft bgs)	Groundwater Elevation (ft msl)
16EW10	13-Feb-04	16.73	173.75	16PM08	18-Feb-04	17.35	173.61
16EW10	14-Feb-04	16.6	173.88	16PM08	19-Feb-04	17.24	173.72
16EW10	15-Feb-04	16.69	173.79	16PM08	20-Feb-04	17.25	173.71
16EW10	16-Feb-04	16.7	173.78	16PM08	23-Feb-04	17.25	173.71
16EW10	17-Feb-04	16.68	173.8	16PM08	25-Feb-04	17.25	173.71
16EW10	18-Feb-04	16.63	173.85	16PM08	27-Feb-04	17.3	173.66
16EW10	19-Feb-04	16.51	173.97	16PM08	5-Mar-04	17.05	173.91
16EW10	20-Feb-04	16.55	173.93	16PM08	9-Mar-04	16.98	173.98
16EW10	22-Feb-04	16.02	174.46	16PM08	17-Mar-04	16.88	174.08
16EW10	23-Feb-04	16.53	173.95	16PM08	22-Mar-04	16.845	174.12
16EW10	25-Feb-04	16.55	173.93	16PM08	24-Mar-04	16.86	174.1
16EW10	27-Feb-04	16.55	173.93	16PM08	20-Apr-04	16.67	174.29
16EW10	2-Mar-04	16.45	174.03	16PM08	5-May-04	16.7	174.26
16EW10	5-Mar-04	16.31	174.17	16PM08	18-May-04	16.61	174.35
16EW10	9-Mar-04	16.25	174.23	16PM08	2-Jun-04	16.65	174.31
16EW10	17-Mar-04	16.15	174.33	16PM08	14-Jun-04	16.5	174.46
16EW10	22-Mar-04	16.12	174.36	16PM08	7-Jul-04	16.2	174.76
16EW10	24-Mar-04	16.13	174.35	16PM08	3-Aug-04	16.32	174.64
16EW10	20-Apr-04	15.95	174.53	16PM08	28-Sep-04	17.15	173.81
16EW10	5-May-04	16.25	174.23	16PM08	30-Nov-04	17	173.96
16EW10	18-May-04	15.88	174.6	16PM08	25-Jan-05	16.12	174.84
16EW10	2-Jun-04	15.94	174.54	16PM08	8-Mar-05	15.91	175.05
16EW10	14-Jun-04	15.8	174.68	16PM08	24-May-05	15.93	175.03
16EW10	7-Jul-04	15.5	174.98	16PM08	18-Oct-05	17.65	173.31
16EW10	3-Aug-04	15.62	174.86	16PM08	1-Nov-05	17.51	173.45
16EW10	28-Sep-04	16.45	174.03	16PM08	19-Dec-05	17.97	172.99
16EW10	30-Nov-04	16.3	174.18	16PM08	30-Jan-06	18.08	172.88
16EW10	25-Jan-05	15.42	175.06	16PM08	14-Mar-06	18.03	172.93
16EW10	8-Mar-05	15.2	175.28	16PM08	8-May-06	17.68	173.28
16EW10	24-May-05	15.22	175.26	16PM08	22-Jun-06	18.12	172.84
16EW10	18-Oct-05	16.93	173.55	16PM09	1-Jul-03	13.1	175.16
16EW10	1-Nov-05	16.98	173.5	16PM09	1-Jul-03	13.12	175.14
16EW10	19-Dec-05	17.27	173.21	16PM09	1-Jul-03	12.975	175.29
16EW10	30-Jan-06	17.31	173.17	16PM09	1-Jul-03	12.96	175.3
16EW10	15-Mar-06	17.26	173.22	16PM09	2-Jul-03	12.96	175.3
16EW10	8-May-06	16.9	173.58	16PM09	8-Dec-03	14.37	173.89
16EW10	22-Jun-06	17.35	173.13	16PM09	8-Dec-03	14.32	173.94
16EW11	1-Jul-03	18.03	175.4	16PM09	8-Dec-03	14.34	173.92
16EW11	2-Jul-03	18.03	175.4	16PM09	9-Dec-03	13.85	174.41
16EW11	8-Dec-03	19.46	173.97	16PM09	9-Dec-03	14.36	173.9
16EW11	8-Dec-03	19.41	174.02	16PM09	10-Dec-03	14.38	173.88
16EW11	8-Dec-03	19.45	173.98	16PM09	10-Dec-03	13.98	174.28
16EW11	9-Dec-03	19.32	174.11	16PM09	11-Dec-03	14.4	173.86
16EW11	9-Dec-03	19.45	173.98	16PM09	12-Dec-03	14.4	173.86
16EW11	10-Dec-03	19.37	174.06	16PM09	9-Feb-04	14.53	173.73
16EW11	10-Dec-03	19.49	173.94	16PM09	12-Feb-04	14.49	173.77
16EW11	11-Dec-03	19.48	173.95	16PM09	13-Feb-04	14.46	173.8
16EW11	12-Dec-03	19.48	173.95	16PM09	18-Feb-04	14.375	173.89

TABLE E-1: GROUNDWATER ELEVATION DATA.
Site 16 Landfill, LHAAP, Karnack, Texas

Location	Date Sampled	Depth to Groundwater (ft bgs)	Groundwater Elevation (ft msl)
16EW11	9-Feb-04	19.62	173.81
16EW11	11-Feb-04	15.27	178.16
16EW11	12-Feb-04	14.88	178.55
16EW11	12-Feb-04	15.01	178.42
16EW11	12-Feb-04	15.27	178.16
16EW11	12-Feb-04	14.88	178.55
16EW11	13-Feb-04	14.48	178.95
16EW11	13-Feb-04	14.57	178.86
16EW11	13-Feb-04	14.48	178.95
16EW11	14-Feb-04	13.78	179.65
16EW11	14-Feb-04	14.11	179.32
16EW11	15-Feb-04	13.57	179.86
16EW11	15-Feb-04	13.72	179.71
16EW11	15-Feb-04	13.57	179.86
16EW11	16-Feb-04	13.02	180.41
16EW11	16-Feb-04	13.22	180.21
16EW11	16-Feb-04	13.02	180.41
16EW11	17-Feb-04	12.63	180.8
16EW11	17-Feb-04	12.68	180.75
16EW11	17-Feb-04	12.63	180.8
16EW11	18-Feb-04	12.31	181.12
16EW11	19-Feb-04	12	181.43
16EW11	20-Feb-04	11.9	181.53
16EW11	22-Feb-04	11.68	181.75
16EW11	23-Feb-04	11.56	181.87
16EW11	24-Feb-04	11.56	181.87
16EW11	25-Feb-04	11.55	181.88
16EW11	26-Feb-04	11.56	181.87
16EW11	27-Feb-04	11.55	181.88
16EW11	1-Mar-04	11.47	181.96
16EW11	2-Mar-04	11.55	181.88
16EW11	3-Mar-04	10.51	182.92
16EW11	4-Mar-04	11.43	182
16EW11	5-Mar-04	11.32	182.11
16EW11	6-Mar-04	11.45	181.98
16EW11	8-Mar-04	11.4	182.03
16EW11	9-Mar-04	11.3	182.13
16EW11	10-Mar-04	11.87	181.56
16EW11	11-Mar-04	11.9	181.53
16EW11	15-Mar-04	11.89	181.54
16EW11	17-Mar-04	11.5	181.93
16EW11	19-Mar-04	11.55	181.88
16EW11	22-Mar-04	11.3	182.13
16EW11	24-Mar-04	11.19	182.24
16EW11	27-Mar-04	10.48	182.95
16EW11	29-Mar-04	10.03	183.4
16EW11	31-Mar-04	9.7	183.73
16EW11	2-Apr-04	10.22	183.21

Location	Date Sampled	Depth to Groundwater (ft bgs)	Groundwater Elevation (ft msl)
16PM09	19-Feb-04	14.22	174.04
16PM09	20-Feb-04	14.25	174.01
16PM09	23-Feb-04	14.26	174
16PM09	25-Feb-04	14.25	174.01
16PM09	27-Feb-04	14.3	173.96
16PM09	5-Mar-04	14	174.26
16PM09	9-Mar-04	13.99	174.27
16PM09	17-Mar-04	13.88	174.38
16PM09	22-Mar-04	13.88	174.38
16PM09	24-Mar-04	13.88	174.38
16PM09	20-Apr-04	13.82	174.44
16PM09	4-May-04	13.8	174.46
16PM09	18-May-04	13.77	174.49
16PM09	2-Jun-04	13.85	174.41
16PM09	14-Jun-04	13.65	174.61
16PM09	7-Jul-04	13.35	174.91
16PM09	3-Aug-04	13.5	174.76
16PM09	28-Sep-04	14.33	173.93
16PM09	30-Nov-04	14.12	174.14
16PM09	25-Jan-05	13.22	175.04
16PM09	8-Mar-05	13.04	175.22
16PM09	24-May-05	13.11	175.15
16PM09	18-Oct-05	14.8	173.46
16PM09	1-Nov-05	15.05	173.21
16PM09	19-Dec-05	15.13	173.13
16PM09	30-Jan-06	15.21	173.05
16PM09	15-Mar-06	15.22	173.04
16PM09	8-May-06	14.8	173.46
16PM09	20-Jun-06	15.29	172.97
16PM10-D	1-Jul-03	14.43	175.21
16PM10-D	2-Jul-03	14.43	175.21
16PM10-D	8-Dec-03	15.87	173.77
16PM10-D	8-Dec-03	15.78	173.86
16PM10-D	8-Dec-03	15.79	173.85
16PM10-D	9-Dec-03	15.52	174.12
16PM10-D	9-Dec-03	15.82	173.82
16PM10-D	10-Dec-03	15.81	173.83
16PM10-D	10-Dec-03	15.49	174.15
16PM10-D	11-Dec-03	15.84	173.8
16PM10-D	12-Dec-03	15.87	173.77
16PM10-D	12-Dec-03	15.86	173.78
16PM10-D	9-Feb-04	15.98	173.66
16PM10-D	23-Feb-04	16.09	173.55
16PM10-D	23-Feb-04	17.27	172.37
16PM10-D	25-Feb-04	17.2	172.44
16PM10-D	25-Feb-04	16.1	173.54
16PM10-D	27-Feb-04	16.1	173.54
16PM10-D	27-Feb-04	17.25	172.39

TABLE E-1: GROUNDWATER ELEVATION DATA.
Site 16 Landfill, LHAAP, Karnack, Texas

Location	Date Sampled	Depth to Groundwater (ft bgs)	Groundwater Elevation (ft msl)
16EW11	5-Apr-04	9.78	183.65
16EW11	7-Apr-04	9.3	184.13
16EW11	8-Apr-04	10.15	183.28
16EW11	13-Apr-04	9.17	184.26
16EW11	14-Apr-04	8.75	184.68
16EW11	20-Apr-04	18.95	174.48
16EW11	18-May-04	18.9	174.53
16EW11	2-Jun-04	19.18	174.25
16EW11	14-Jun-04	19.55	173.88
16EW11	7-Jul-04	18.5	174.93
16EW11	3-Aug-04	18.6	174.83
16EW11	28-Sep-04	21.41	172.02
16EW11	30-Nov-04	19.25	174.18
16EW11	14-Dec-04	13.38	180.05
16EW11	16-Dec-04	13.05	180.38
16EW11	17-Dec-04	12.88	180.55
16EW11	20-Dec-04	12.49	180.94
16EW11	28-Dec-04	13.2	180.23
16EW11	25-Jan-05	18.41	175.02
16EW11	8-Mar-05	18.15	175.28
16EW11	24-May-05	18.16	175.27
16EW11	18-Oct-05	19.88	173.55
16EW11	1-Nov-05	19.9	173.53
16EW11	19-Dec-05	20.24	173.19
16EW11	30-Jan-06	20.34	173.09
16EW11	8-May-06	19.92	173.51
16EW11	20-Jun-06	20.37	173.06
16EW12	1-Jul-03	15.24	175.19
16EW12	2-Jul-03	15.24	175.19
16EW12	8-Dec-03	19.37	171.06
16EW12	8-Dec-03	19.74	170.69
16EW12	8-Dec-03	20.05	170.38
16EW12	9-Dec-03	16.85	173.58
16EW12	9-Dec-03	21.16	169.27
16EW12	10-Dec-03	16.31	174.12
16EW12	10-Dec-03	16.77	173.66
16EW12	11-Dec-03	16.69	173.74
16EW12	12-Dec-03	16.69	173.74
16EW12	9-Feb-04	16.83	173.6
16EW12	11-Feb-04	16.91	173.52
16EW12	12-Feb-04	16.97	173.46
16EW12	12-Feb-04	16.91	173.52
16EW12	18-Feb-04	16.86	173.57
16EW12	19-Feb-04	16.73	173.7
16EW12	20-Feb-04	16.74	173.69
16EW12	23-Feb-04	16.72	173.71
16EW12	25-Feb-04	16.8	173.63
16EW12	27-Feb-04	16.8	173.63

Location	Date Sampled	Depth to Groundwater (ft bgs)	Groundwater Elevation (ft msl)
16PM10-D	4-May-04	15.35	174.29
16PM10-D	19-May-04	15.4	174.24
16PM10-D	3-Jun-04	15.25	174.39
16PM10-D	14-Jun-04	15.35	174.29
16PM10-D	7-Jul-04	15	174.64
16PM10-D	3-Aug-04	15.2	174.44
16PM10-D	28-Sep-04	15.75	173.89
16PM10-D	30-Nov-04	15.6	174.04
16PM10-D	25-Jan-05	14.98	174.66
16PM10-D	8-Mar-05	14.5	175.14
16PM10-D	24-May-05	14.54	175.1
16PM10-D	18-Oct-05	16.2	173.44
16PM10-D	1-Nov-05	17.15	172.49
16PM10-D	19-Dec-05	16.53	173.11
16PM10-D	30-Jan-06	16.63	173.01
16PM10-D	14-Mar-06	16.69	172.95
16PM10-D	8-May-06	16.27	173.37
16PM10-D	20-Jun-06	16.79	172.85
16PM10-S	1-Jul-03	14.48	175.15
16PM10-S	2-Jul-03	14.48	175.15
16PM10-S	8-Dec-03	15.95	173.68
16PM10-S	8-Dec-03	15.9	173.73
16PM10-S	8-Dec-03	15.84	173.79
16PM10-S	9-Dec-03	15.48	174.15
16PM10-S	9-Dec-03	15.86	173.77
16PM10-S	10-Dec-03	15.84	173.79
16PM10-S	10-Dec-03	15.68	173.95
16PM10-S	11-Dec-03	15.89	173.74
16PM10-S	12-Dec-03	15.89	173.74
16PM10-S	12-Dec-03	15.91	173.72
16PM10-S	9-Feb-04	16.04	173.59
16PM10-S	23-Feb-04	15.96	173.67
16PM10-S	23-Feb-04	16.09	173.54
16PM10-S	25-Feb-04	15.95	173.68
16PM10-S	25-Feb-04	16.1	173.53
16PM10-S	27-Feb-04	16	173.63
16PM10-S	27-Feb-04	16.1	173.53
16PM10-S	4-May-04	15.5	174.13
16PM10-S	19-May-04	15.55	174.08
16PM10-S	3-Jun-04	15.4	174.23
16PM10-S	14-Jun-04	15.35	174.28
16PM10-S	7-Jul-04	15.15	174.48
16PM10-S	3-Aug-04	15.3	174.33
16PM10-S	28-Sep-04	15.85	173.78
16PM10-S	30-Nov-04	15.65	173.98
16PM10-S	25-Jan-05	14.85	174.78
16PM10-S	8-Mar-05	14.57	175.06
16PM10-S	24-May-05	14.65	174.98

TABLE E-1: GROUNDWATER ELEVATION DATA.
Site 16 Landfill, LHAAP, Karnack, Texas

Location	Date Sampled	Depth to Groundwater (ft bgs)	Groundwater Elevation (ft msl)
16EW12	2-Mar-04	16.7	173.73
16EW12	5-Mar-04	16.55	173.88
16EW12	9-Mar-04	16.48	173.95
16EW12	17-Mar-04	16.4	174.03
16EW12	22-Mar-04	16.36	174.07
16EW12	24-Mar-04	16.35	174.08
16EW12	20-Apr-04	16.15	174.28
16EW12	18-May-04	16.08	174.35
16EW12	2-Jun-04	16.4	174.03
16EW12	14-Jun-04	17.01	173.42
16EW12	7-Jul-04	15.7	174.73
16EW12	3-Aug-04	15.8	174.63
16EW12	28-Sep-04	16.6	173.83
16EW12	30-Nov-04	16.47	173.96
16EW12	14-Dec-04	16.51	173.92
16EW12	16-Dec-04	16.34	174.09
16EW12	17-Dec-04	16.26	174.17
16EW12	20-Dec-04	16.16	174.27
16EW12	28-Dec-04	16.21	174.22
16EW12	25-Jan-05	15.58	174.85
16EW12	8-Mar-05	15.36	175.07
16EW12	24-May-05	15.37	175.06
16EW12	18-Oct-05	17.1	173.33
16EW12	1-Nov-05	11.7	178.73
16EW12	19-Dec-05	11.43	179.00
16EW12	30-Jan-06	17.51	172.92
16EW12	16-Mar-06	17.46	172.97
16EW12	8-May-06	17.1	173.33
16EW12	22-Jun-06	17.55	172.88
16EW13	1-Jul-03	14.67	175.22
16EW13	1-Jul-03	14.69	175.2
16EW13	1-Jul-03	14.7	175.19
16EW13	1-Jul-03	14.67	175.22
16EW13	2-Jul-03	14.65	175.24
16EW13	8-Dec-03	15.67	174.22
16EW13	8-Dec-03	15.62	174.27
16EW13	8-Dec-03	15.64	174.25
16EW13	9-Dec-03	15.64	174.25
16EW13	9-Dec-03	15.61	174.28
16EW13	10-Dec-03	16.03	173.86
16EW13	10-Dec-03	15.86	174.03
16EW13	11-Dec-03	16.06	173.83
16EW13	12-Dec-03	16.045	173.85
16EW13	12-Dec-03	16.1	173.79
16EW13	9-Feb-04	16.25	173.64
16EW13	11-Feb-04	10.815	179.08
16EW13	12-Feb-04	10.52	179.37
16EW13	12-Feb-04	10.56	179.33

Location	Date Sampled	Depth to Groundwater (ft bgs)	Groundwater Elevation (ft msl)
16PM10-S	18-Oct-05	16.3	173.33
16PM10-S	1-Nov-05	16.43	173.2
16PM10-S	19-Dec-05	16.62	173.01
16PM10-S	30-Jan-06	16.71	172.92
16PM10-S	14-Mar-06	16.71	172.92
16PM10-S	8-May-06	16.36	173.27
16PM10-S	20-Jun-06	16.82	172.81
16PM11	1-Jul-03	15.8	175.11
16PM11	2-Jul-03	15.79	175.12
16PM11	8-Dec-03	17.22	173.69
16PM11	8-Dec-03	17.11	173.8
16PM11	8-Dec-03	17.18	173.73
16PM11	9-Dec-03	16.98	173.93
16PM11	9-Dec-03	17.22	173.69
16PM11	10-Dec-03	17.14	173.77
16PM11	10-Dec-03	17.19	173.72
16PM11	11-Dec-03	17.23	173.68
16PM11	12-Dec-03	17.23	173.68
16PM11	9-Feb-04	17.38	173.53
16PM11	12-Feb-04	17.43	173.48
16PM11	18-Feb-04	17.32	173.59
16PM11	19-Feb-04	17.2	173.71
16PM11	20-Feb-04	17.25	173.66
16PM11	23-Feb-04	15.96	174.95
16PM11	23-Feb-04	17.27	173.64
16PM11	25-Feb-04	17.2	173.71
16PM11	25-Feb-04	15.95	174.96
16PM11	27-Feb-04	16	174.91
16PM11	27-Feb-04	17.25	173.66
16PM11	5-Mar-04	17	173.91
16PM11	9-Mar-04	16.94	173.97
16PM11	17-Mar-04	16.85	174.06
16PM11	22-Mar-04	16.83	174.08
16PM11	24-Mar-04	16.82	174.09
16PM11	20-Apr-04	16.69	174.22
16PM11	5-May-04	16.7	174.21
16PM11	18-May-04	16.61	174.3
16PM11	2-Jun-04	16.67	174.24
16PM11	14-Jun-04	16.52	174.39
16PM11	7-Jul-04	16.22	174.69
16PM11	3-Aug-04	16.34	174.57
16PM11	28-Sep-04	17.15	173.76
16PM11	30-Nov-04	17.02	173.89
16PM11	25-Jan-05	16.16	174.75
16PM11	8-Mar-05	15.96	174.95
16PM11	24-May-05	15.97	174.94
16PM11	18-Oct-05	17.68	173.23
16PM11	1-Nov-05	17.6	173.31

TABLE E-1: GROUNDWATER ELEVATION DATA.
Site 16 Landfill, LHAAP, Karnack, Texas

Location	Date Sampled	Depth to Groundwater (ft bgs)	Groundwater Elevation (ft msl)
16EW13	12-Feb-04	10.815	179.08
16EW13	12-Feb-04	10.52	179.37
16EW13	13-Feb-04	10.31	179.58
16EW13	13-Feb-04	10.42	179.47
16EW13	13-Feb-04	10.31	179.58
16EW13	14-Feb-04	10.15	179.74
16EW13	14-Feb-04	10.18	179.71
16EW13	14-Feb-04	10.15	179.74
16EW13	15-Feb-04	10.15	179.74
16EW13	15-Feb-04	10.19	179.7
16EW13	15-Feb-04	10.15	179.74
16EW13	16-Feb-04	10.11	179.78
16EW13	16-Feb-04	10.17	179.72
16EW13	16-Feb-04	10.11	179.78
16EW13	17-Feb-04	10.42	179.47
16EW13	17-Feb-04	10.13	179.76
16EW13	17-Feb-04	10.42	179.47
16EW13	18-Feb-04	10.35	179.54
16EW13	19-Feb-04	10.25	179.64
16EW13	20-Feb-04	10.23	179.66
16EW13	22-Feb-04	10.35	179.54
16EW13	23-Feb-04	10.19	179.7
16EW13	24-Feb-04	10.8	179.09
16EW13	25-Feb-04	10.8	179.09
16EW13	26-Feb-04	10.8	179.09
16EW13	27-Feb-04	10.45	179.44
16EW13	1-Mar-04	10.14	179.75
16EW13	2-Mar-04	10.28	179.61
16EW13	3-Mar-04	10.11	179.78
16EW13	4-Mar-04	10.4	179.49
16EW13	5-Mar-04	9.6	180.29
16EW13	6-Mar-04	10.55	179.34
16EW13	8-Mar-04	9.6	180.29
16EW13	9-Mar-04	9.27	180.62
16EW13	10-Mar-04	9.4	180.49
16EW13	11-Mar-04	11.37	178.52
16EW13	15-Mar-04	9.01	180.88
16EW13	17-Mar-04	8.82	181.07
16EW13	19-Mar-04	9	180.89
16EW13	22-Mar-04	9.23	180.66
16EW13	24-Mar-04	8.77	181.12
16EW13	27-Mar-04	8.75	181.14
16EW13	29-Mar-04	8.35	181.54
16EW13	31-Mar-04	8.25	181.64
16EW13	2-Apr-04	8.56	181.33
16EW13	5-Apr-04	8.4	181.49
16EW13	7-Apr-04	8.3	181.59
16EW13	8-Apr-04	8.32	181.57

Location	Date Sampled	Depth to Groundwater (ft bgs)	Groundwater Elevation (ft msl)
16PM11	19-Dec-05	17.99	172.92
16PM11	30-Jan-06	18.09	172.82
16PM11	14-Mar-06	18.03	172.88
16PM11	8-May-06	17.67	173.24
16PM11	22-Jun-06	18.12	172.79
16PM12	1-Jul-03	12.96	175.13
16PM12	1-Jul-03	12.99	175.1
16PM12	1-Jul-03	12.89	175.2
16PM12	1-Jul-03	12.97	175.12
16PM12	2-Jul-03	12.86	175.23
16PM12	8-Dec-03	14.25	173.84
16PM12	8-Dec-03	14.21	173.88
16PM12	8-Dec-03	14.24	173.85
16PM12	9-Dec-03	13.81	174.28
16PM12	9-Dec-03	14.29	173.8
16PM12	10-Dec-03	14.28	173.81
16PM12	10-Dec-03	13.98	174.11
16PM12	11-Dec-03	14.3	173.79
16PM12	12-Dec-03	14.28	173.81
16PM12	12-Dec-03	14.31	173.78
16PM12	9-Feb-04	14.43	173.66
16PM12	12-Feb-04	14.47	173.62
16PM12	18-Feb-04	14.32	173.77
16PM12	19-Feb-04	14.17	173.92
16PM12	20-Feb-04	14.25	173.84
16PM12	23-Feb-04	14.2	173.89
16PM12	25-Feb-04	14.2	173.89
16PM12	27-Feb-04	14.25	173.84
16PM12	5-Mar-04	13.91	174.18
16PM12	9-Mar-04	13.93	174.16
16PM12	17-Mar-04	13.8	174.29
16PM12	22-Mar-04	13.82	174.27
16PM12	24-Mar-04	13.79	174.3
16PM12	20-Apr-04	13.7	174.39
16PM12	4-May-04	13.65	174.44
16PM12	18-May-04	13.66	174.43
16PM12	2-Jun-04	13.73	174.36
16PM12	14-Jun-04	13.52	174.57
16PM12	7-Jul-04	13.25	174.84
16PM12	3-Aug-04	13.38	174.71
16PM12	28-Sep-04	14.21	173.88
16PM12	30-Nov-04	14	174.09
16PM12	25-Jan-05	13.12	174.97
16PM12	8-Mar-05	12.95	175.14
16PM12	24-May-05	13.01	175.08
16PM12	18-Oct-05	14.71	173.38
16PM12	1-Nov-05	15	173.09
16PM12	19-Dec-05	15.02	173.07

TABLE E-1: GROUNDWATER ELEVATION DATA.
Site 16 Landfill, LHAAP, Karnack, Texas

Location	Date Sampled	Depth to Groundwater (ft bgs)	Groundwater Elevation (ft msl)	Location	Date Sampled	Depth to Groundwater (ft bgs)	Groundwater Elevation (ft msl)
16EW13	13-Apr-04	8.96	180.93	16PM12	30-Jan-06	15.12	172.97
16EW13	14-Apr-04	9.37	180.52	16PM12	15-Mar-06	15.1	172.99
16EW13	20-Apr-04	15.55	174.34	16PM12	8-May-06	14.69	173.4
16EW13	18-May-04	15.5	174.39	16PM12	20-Jun-06	15.18	172.91
16EW13	2-Jun-04	15.55	174.34	16PM13-D	2-Jul-03	14.685	175.12
16EW13	14-Jun-04	15.4	174.49	16PM13-D	8-Dec-03	16.13	173.67
16EW13	7-Jul-04	15.1	174.79	16PM13-D	8-Dec-03	16.1	173.7
16EW13	3-Aug-04	15.2	174.69	16PM13-D	8-Dec-03	16.06	173.74
16EW13	28-Sep-04	16	173.89	16PM13-D	9-Dec-03	15.71	174.09
16EW13	30-Nov-04	15.86	174.03	16PM13-D	9-Dec-03	16.07	173.73
16EW13	14-Dec-04	7.12	182.77	16PM13-D	10-Dec-03	16.04	173.76
16EW13	16-Dec-04	7.05	182.84	16PM13-D	10-Dec-03	15.92	173.88
16EW13	17-Dec-04	7.15	182.74	16PM13-D	11-Dec-03	16.09	173.71
16EW13	20-Dec-04	7.32	182.57	16PM13-D	12-Dec-03	16.09	173.71
16EW13	28-Dec-04	8.12	181.77	16PM13-D	12-Dec-03	16.1	173.7
16EW13	25-Jan-05	14.95	174.94	16PM13-D	9-Feb-04	16.23	173.57
16EW13	8-Mar-05	14.75	175.14	16PM13-D	23-Feb-04	16.45	173.35
16EW13	24-May-05	14.79	175.1	16PM13-D	25-Feb-04	16.4	173.4
16EW13	18-Oct-05	16.45	173.44	16PM13-D	27-Feb-04	16.4	173.4
16EW13	1-Nov-05	16.58	173.31	16PM13-D	5-May-04	15.52	174.28
16EW13	19-Dec-05	16.85	173.04	16PM13-D	19-May-04	15.7	174.1
16EW13	30-Jan-06	16.92	172.97	16PM13-D	3-Jun-04	15.53	174.27
16EW13	8-May-06	16.5	173.39	16PM13-D	14-Jun-04	15.55	174.25
16EW13	20-Jun-06	16.95	172.94	16PM13-D	7-Jul-04	15.5	174.3
16EW14	1-Jul-03	14.51	175.26	16PM13-D	3-Aug-04	15.7	174.1
16EW14	1-Jul-03	14.53	175.24	16PM13-D	28-Sep-04	15.95	173.85
16EW14	1-Jul-03	14.47	175.3	16PM13-D	30-Nov-04	15.8	174
16EW14	1-Jul-03	14.46	175.31	16PM13-D	25-Jan-05	15	174.8
16EW14	2-Jul-03	14.465	175.31	16PM13-D	8-Mar-05	14.74	175.06
16EW14	8-Dec-03	15.91	173.86	16PM13-D	14-Mar-05	16.85	172.95
16EW14	8-Dec-03	15.87	173.9	16PM13-D	24-May-05	14.75	175.05
16EW14	9-Dec-03	11.48	178.29	16PM13-D	18-Oct-05	16.45	173.35
16EW14	9-Dec-03	15.9	173.87	16PM13-D	1-Nov-05	16.65	173.15
16EW14	10-Dec-03	15.97	173.8	16PM13-D	19-Dec-05	16.79	173.01
16EW14	11-Dec-03	19.91	169.86	16PM13-D	30-Jan-06	16.88	172.92
16EW14	12-Dec-03	15.91	173.86	16PM13-D	8-May-06	16.48	173.32
16EW14	9-Feb-04	16.04	173.73	16PM13-D	22-Jun-06	16.94	172.86
16EW14	11-Feb-04	16.94	172.83	16PM13-S	1-Jul-03	14.81	174.99
16EW14	12-Feb-04	17.1	172.67	16PM13-S	2-Jul-03	14.815	174.99
16EW14	12-Feb-04	16.99	172.78	16PM13-S	8-Dec-03	16.25	173.55
16EW14	18-Feb-04	16.95	172.82	16PM13-S	8-Dec-03	16.2	173.6
16EW14	19-Feb-04	16.83	172.94	16PM13-S	8-Dec-03	16.19	173.61
16EW14	20-Feb-04	16.8	172.97	16PM13-S	9-Dec-03	15.99	173.81
16EW14	23-Feb-04	16.76	173.01	16PM13-S	9-Dec-03	16.22	173.58
16EW14	25-Feb-04	17.1	172.67	16PM13-S	10-Dec-03	16.18	173.62
16EW14	27-Feb-04	16.8	172.97	16PM13-S	10-Dec-03	16.21	173.59
16EW14	2-Mar-04	16.68	173.09	16PM13-S	11-Dec-03	16.22	173.58
16EW14	5-Mar-04	16.47	173.3	16PM13-S	12-Dec-03	16.24	173.56

TABLE E-1: GROUNDWATER ELEVATION DATA.
Site 16 Landfill, LHAAP, Karnack, Texas

Location	Date Sampled	Depth to Groundwater (ft bgs)	Groundwater Elevation (ft msl)
16EW14	9-Mar-04	16.51	173.26
16EW14	17-Mar-04	16.35	173.42
16EW14	22-Mar-04	16.32	173.45
16EW14	24-Mar-04	16.32	173.45
16EW14	29-Mar-04	16.31	173.46
16EW14	20-Apr-04	15.36	174.41
16EW14	18-May-04	15.27	174.5
16EW14	2-Jun-04	15.2	174.57
16EW14	14-Jun-04	15.15	174.62
16EW14	7-Jul-04	14.86	174.91
16EW14	3-Aug-04	14.98	174.79
16EW14	28-Sep-04	15.85	173.92
16EW14	30-Nov-04	15.8	173.97
16EW14	14-Dec-04	15.76	174.01
16EW14	16-Dec-04	15.57	174.2
16EW14	17-Dec-04	15.5	174.27
16EW14	20-Dec-04	15.41	174.36
16EW14	28-Dec-04	15.35	174.42
16EW14	25-Jan-05	14.75	175.02
16EW14	8-Mar-05	14.51	175.26
16EW14	24-May-05	14.51	175.26
16EW14	18-Oct-05	16.29	173.48
16EW14	1-Nov-05	16.85	172.92
16EW14	19-Dec-05	16.6	173.17
16EW14	30-Jan-06	16.71	173.06
16EW14	8-May-06	16.29	173.48
16EW14	20-Jun-06	16.75	173.02
16EW15	1-Jul-03	14.495	175.33
16EW15	1-Jul-03	14.49	175.33
16EW15	2-Jul-03	14.49	175.33
16EW15	8-Dec-03	15.86	173.96
16EW15	8-Dec-03	15.85	173.97
16EW15	8-Dec-03	15.88	173.94
16EW15	9-Dec-03	15.48	174.34
16EW15	9-Dec-03	15.89	173.93
16EW15	10-Dec-03	15.93	173.89
16EW15	10-Dec-03	15.67	174.15
16EW15	11-Dec-03	15.91	173.91
16EW15	12-Dec-03	15.9	173.92
16EW15	12-Dec-03	15.92	173.9
16EW15	9-Feb-04	16.03	173.79
16EW15	11-Feb-04	5.41	184.41
16EW15	12-Feb-04	4.78	185.04
16EW15	12-Feb-04	4.93	184.89
16EW15	12-Feb-04	5.41	184.41
16EW15	12-Feb-04	4.78	185.04
16EW15	13-Feb-04	4.42	185.4
16EW15	13-Feb-04	4.6	185.22

Location	Date Sampled	Depth to Groundwater (ft bgs)	Groundwater Elevation (ft msl)
16PM13-S	12-Dec-03	16.25	173.55
16PM13-S	9-Feb-04	16.37	173.43
16PM13-S	23-Feb-04	16.33	173.47
16PM13-S	25-Feb-04	16.25	173.55
16PM13-S	27-Feb-04	16.25	173.55
16PM13-S	5-May-04	15.8	174
16PM13-S	19-May-04	15.7	174.1
16PM13-S	3-Jun-04	15.71	174.09
16PM13-S	14-Jun-04	15.6	174.2
16PM13-S	7-Jul-04	15.35	174.45
16PM13-S	3-Aug-04	15.5	174.3
16PM13-S	28-Sep-04	16.18	173.62
16PM13-S	30-Nov-04	16	173.8
16PM13-S	25-Jan-05	15.2	174.6
16PM13-S	8-Mar-05	14.92	174.88
16PM13-S	14-Mar-05	17.04	172.76
16PM13-S	24-May-05	14.95	174.85
16PM13-S	18-Oct-05	16.65	173.15
16PM13-S	1-Nov-05	16.75	173.05
16PM13-S	19-Dec-05	16.97	172.83
16PM13-S	30-Jan-06	17.04	172.76
16PM13-S	8-May-06	16.67	173.13
16PM13-S	22-Jun-06	17.12	172.68
16PM14	1-Jul-03	16.145	175.04
16PM14	2-Jul-03	16.135	175.05
16PM14	8-Dec-03	17.53	173.65
16PM14	8-Dec-03	17.49	173.69
16PM14	8-Dec-03	17.51	173.67
16PM14	9-Dec-03	17.34	173.84
16PM14	9-Dec-03	17.55	173.63
16PM14	10-Dec-03	17.47	173.71
16PM14	10-Dec-03	17.56	173.62
16PM14	11-Dec-03	17.57	173.61
16PM14	12-Dec-03	17.55	173.63
16PM14	12-Dec-03	17.57	173.61
16PM14	9-Feb-04	17.71	173.47
16PM14	12-Feb-04	17.76	173.42
16PM14	18-Feb-04	17.66	173.52
16PM14	19-Feb-04	17.55	173.63
16PM14	20-Feb-04	17.55	173.63
16PM14	23-Feb-04	17.55	173.63
16PM14	25-Feb-04	17.55	173.63
16PM14	27-Feb-04	17.6	173.58
16PM14	5-Mar-04	17.35	173.83
16PM14	9-Mar-04	17.27	173.91
16PM14	17-Mar-04	17.16	174.02
16PM14	22-Mar-04	17.14	174.04
16PM14	24-Mar-04	17.14	174.04

TABLE E-1: GROUNDWATER ELEVATION DATA.
Site 16 Landfill, LHAAP, Karnack, Texas

Location	Date Sampled	Depth to Groundwater (ft bgs)	Groundwater Elevation (ft msl)	Location	Date Sampled	Depth to Groundwater (ft bgs)	Groundwater Elevation (ft msl)
16EW15	13-Feb-04	4.42	185.4	16PM14	20-Apr-04	17.02	174.16
16EW15	14-Feb-04	4.14	185.68	16PM14	5-May-04	17	174.18
16EW15	14-Feb-04	4.22	185.6	16PM14	18-May-04	16.95	174.23
16EW15	14-Feb-04	4.14	185.68	16PM14	2-Jun-04	17	174.18
16EW15	15-Feb-04	4.08	185.74	16PM14	14-Jun-04	16.85	174.33
16EW15	15-Feb-04	4	185.82	16PM14	7-Jul-04	16.55	174.63
16EW15	15-Feb-04	4.08	185.74	16PM14	3-Aug-04	16.67	174.51
16EW15	16-Feb-04	4.07	185.75	16PM14	28-Sep-04	17.48	173.7
16EW15	16-Feb-04	4.04	185.78	16PM14	30-Nov-04	17.38	173.8
16EW15	16-Feb-04	4.07	185.75	16PM14	25-Jan-05	16.47	174.71
16EW15	17-Feb-04	4.07	185.75	16PM14	8-Mar-05	16.27	174.91
16EW15	17-Feb-04	3.96	185.86	16PM14	14-Mar-05	18.35	172.83
16EW15	17-Feb-04	4.07	185.75	16PM14	24-May-05	16.3	174.88
16EW15	18-Feb-04	4.15	185.67	16PM14	18-Oct-05	18	173.18
16EW15	19-Feb-04	4.5	185.32	16PM14	1-Nov-05	18	173.18
16EW15	20-Feb-04	4.05	185.77	16PM14	19-Dec-05	18.31	172.87
16EW15	22-Feb-04	4.18	185.64	16PM14	30-Jan-06	18.4	172.78
16EW15	23-Feb-04	3.96	185.86	16PM14	8-May-06	17.99	173.19
16EW15	24-Feb-04	3.8	186.02	16PM14	22-Jun-06	18.45	172.73
16EW15	25-Feb-04	3.85	185.97	16WW14	1-Jul-03	23.76	174.89
16EW15	26-Feb-04	3.75	186.07	16WW14	2-Jul-03	23.82	174.83
16EW15	27-Feb-04	4	185.82	16WW14	8-Dec-03	25.25	173.4
16EW15	1-Mar-04	3.38	186.44	16WW14	10-Dec-03	25.18	173.47
16EW15	2-Mar-04	3.45	186.37	16WW14	12-Dec-03	25.27	173.38
16EW15	3-Mar-04	3.35	186.47	16WW15	8-Dec-03	24.92	173.79
16EW15	4-Mar-04	3.4	186.42	16WW15	10-Dec-03	24.98	173.73
16EW15	5-Mar-04	3.25	186.57	16WW15	12-Dec-03	25.01	173.7
16EW15	6-Mar-04	4.2	185.62	16WW15	11-Feb-04	24.71	174
16EW15	8-Mar-04	3.38	186.44	16WW15	12-Feb-04	24.71	174
16EW15	9-Mar-04	3.07	186.75	16WW15	12-Feb-04	24.7	174.01
16EW15	10-Mar-04	3.15	186.67	16WW15	13-Feb-04	24.68	174.03
16EW15	11-Mar-04	3.06	186.76	16WW15	14-Feb-04	24.58	174.13
16EW15	15-Mar-04	3.4	186.42	16WW15	15-Feb-04	24.59	174.12
16EW15	17-Mar-04	2.98	186.84	16WW15	17-Feb-04	24.64	174.07
16EW15	19-Mar-04	2.95	186.87	16WW15	18-Feb-04	24.64	174.07
16EW15	22-Mar-04	3.61	186.21	16WW15	19-Feb-04	24.55	174.16
16EW15	24-Mar-04	3.02	186.8	16WW15	20-Feb-04	24.5	174.21
16EW15	27-Mar-04	3.7	186.12	16WW15	23-Feb-04	24.71	174
16EW15	29-Mar-04	3.79	186.03	16WW15	25-Feb-04	34.6	164.11
16EW15	31-Mar-04	3.3	186.52	16WW15	27-Feb-04	24.65	174.06
16EW15	2-Apr-04	4.1	185.72	16WW15	5-Mar-04	24.2	174.51
16EW15	5-Apr-04	4.15	185.67	16WW15	9-Mar-04	24.23	174.48
16EW15	7-Apr-04	4.5	185.32	16WW15	17-Mar-04	24.05	174.66
16EW15	8-Apr-04	5.26	184.56	16WW15	24-Mar-04	24.01	174.7
16EW15	13-Apr-04	4.7	185.12	16WW15	20-Apr-04	23.62	175.09
16EW15	14-Apr-04	4.9	184.92	16WW15	18-May-04	23.4	175.31
16EW15	20-Apr-04	15.35	174.47	16WW15	2-Jun-04	23.3	175.41
16EW15	18-May-04	15.32	174.5	16WW15	14-Jun-04	23	175.71

TABLE E-1: GROUNDWATER ELEVATION DATA.
Site 16 Landfill, LHAAP, Karnack, Texas

Location	Date Sampled	Depth to Groundwater (ft bgs)	Groundwater Elevation (ft msl)
16EW15	2-Jun-04	15.85	173.97
16EW15	14-Jun-04	17	172.82
16EW15	7-Jul-04	16	173.82
16EW15	3-Aug-04	15	174.82
16EW15	28-Sep-04	15.85	173.97
16EW15	30-Nov-04	15.65	174.17
16EW15	14-Dec-04	3.42	186.4
16EW15	16-Dec-04	3.9	185.92
16EW15	17-Dec-04	3.92	185.9
16EW15	20-Dec-04	3.88	185.94
16EW15	28-Dec-04	6.3	183.52
16EW15	25-Jan-05	14.7	175.12
16EW15	8-Mar-05	14.55	175.27
16EW15	24-May-05	14.6	175.22
16EW15	18-Oct-05	16.3	173.52
16EW15	1-Nov-05	16.55	173.27
16EW15	19-Dec-05	16.72	173.1
16EW15	30-Jan-06	16.79	173.03
16EW15	8-May-06	16.38	173.44
16EW15	20-Jun-06	16.88	172.94
16PM01	1-Jul-03	15.24	175.26
16PM01	1-Jul-03	15.25	175.25
16PM01	1-Jul-03	15.25	175.25
16PM01	1-Jul-03	15.205	175.3
16PM01	2-Jul-03	15.21	175.29
16PM01	8-Dec-03	16.6	173.9
16PM01	8-Dec-03	16.58	173.92
16PM01	8-Dec-03	16.6	173.9
16PM01	9-Dec-03	16.14	174.36
16PM01	9-Dec-03	16.62	173.88
16PM01	10-Dec-03	16.16	174.34
16PM01	10-Dec-03	16.67	173.83
16PM01	11-Dec-03	16.64	173.86
16PM01	12-Dec-03	16.64	173.86
16PM01	9-Feb-04	16.83	173.67
16PM01	12-Feb-04	16.88	173.62
16PM01	13-Feb-04	16.88	173.62
16PM01	14-Feb-04	16.77	173.73
16PM01	16-Feb-04	16.86	173.64
16PM01	17-Feb-04	16.835	173.67
16PM01	18-Feb-04	16.79	173.71
16PM01	19-Feb-04	16.63	173.87
16PM01	20-Feb-04	16.7	173.8
16PM01	23-Feb-04	16.68	173.82
16PM01	25-Feb-04	16.65	173.85
16PM01	27-Feb-04	16.7	173.8
16PM01	5-Mar-04	16.5	174
16PM01	9-Mar-04	16.4	174.1

Location	Date Sampled	Depth to Groundwater (ft bgs)	Groundwater Elevation (ft msl)
16WW15	7-Jul-04	22.9	175.81
16WW15	3-Aug-04	23.17	175.54
16WW15	28-Sep-04	24.2	174.51
16WW15	30-Nov-04	24.07	174.64
16WW15	25-Jan-05	23.11	175.6
16WW15	8-Mar-05	22.62	176.09
16WW15	24-May-05	22.74	175.97
16WW15	18-Oct-05	25.33	173.38
16WW15	1-Nov-05	25.51	173.2
16WW15	19-Dec-05	25.83	172.88
16WW15	30-Jan-06	25.45	173.26
16WW15	8-May-06	24.53	174.18
16WW15	20-Jun-06	25.1	173.61
16WW16	1-Jul-03	20.43	175.23
16WW16	2-Jul-03	20.41	175.25
16WW16	8-Dec-03	21.83	173.83
16WW16	8-Dec-03	21.8	173.86
16WW16	8-Dec-03	21.8	173.86
16WW16	9-Dec-03	21.64	174.02
16WW16	9-Dec-03	21.83	173.83
16WW16	10-Dec-03	21.81	173.85
16WW16	10-Dec-03	21.89	173.77
16WW16	11-Dec-03	21.86	173.8
16WW16	12-Dec-03	21.86	173.8
16WW16	9-Feb-04	22.02	173.64
16WW16	11-Feb-04	22.03	173.63
16WW16	12-Feb-04	22.11	173.55
16WW16	12-Feb-04	22.03	173.63
16WW16	13-Feb-04	22.17	173.49
16WW16	14-Feb-04	21.97	173.69
16WW16	15-Feb-04	22.045	173.62
16WW16	17-Feb-04	22.05	173.61
16WW16	18-Feb-04	21.99	173.67
16WW16	19-Feb-04	21.85	173.81
16WW16	20-Feb-04	26.81	168.85
16WW16	23-Feb-04	21.86	173.8
16WW16	25-Feb-04	21.85	173.81
16WW16	27-Feb-04	21.9	173.76
16WW16	5-Mar-04	21.61	174.05
16WW16	9-Mar-04	21.59	174.07
16WW16	17-Mar-04	21.48	174.18
16WW16	24-Mar-04	21.4	174.26
16WW16	20-Apr-04	21.28	174.38
16WW16	18-May-04	21.22	174.44
16WW16	2-Jun-04	21.27	174.39
16WW16	14-Jun-04	21.15	174.51
16WW16	7-Jul-04	20.82	174.84
16WW16	3-Aug-04	20.95	174.71

TABLE E-1: GROUNDWATER ELEVATION DATA.
Site 16 Landfill, LHAAP, Karnack, Texas

Location	Date Sampled	Depth to Groundwater (ft bgs)	Groundwater Elevation (ft msl)
16PM01	17-Mar-04	16.3	174.2
16PM01	22-Mar-04	16.2	174.3
16PM01	24-Mar-04	16.27	174.23
16PM01	20-Apr-04	16.08	174.42
16PM01	4-May-04	16.1	174.4
16PM01	18-May-04	16.03	174.47
16PM01	2-Jun-04	16.07	174.43
16PM01	14-Jun-04	15.92	174.58
16PM01	3-Aug-04	15.73	174.77
16PM01	28-Sep-04	16.6	173.9
16PM01	30-Nov-04	16.88	173.62
16PM01	25-Jan-05	15.48	175.02
16PM01	8-Mar-05	15.29	175.21
16PM01	24-May-05	15.3	175.2
16PM01	18-Oct-05	17.25	173.25
16PM01	1-Nov-05	17.15	173.35
16PM01	19-Dec-05	17.4	173.1
16PM01	30-Jan-06	17.55	172.95
16PM01	14-Mar-06	17.41	173.09
16PM01	8-May-06	17.07	173.43
16PM01	20-Jun-06	17.57	172.93
16PM02	1-Jul-03	15.8	175.28
16PM02	1-Jul-03	15.84	175.24
16PM02	1-Jul-03	15.84	175.24
16PM02	1-Jul-03	15.75	175.33
16PM02	2-Jul-03	15.75	175.33
16PM02	8-Dec-03	17.13	173.95
16PM02	8-Dec-03	17.11	173.97
16PM02	8-Dec-03	17.14	173.94
16PM02	9-Dec-03	17.14	173.94
16PM02	10-Dec-03	17.32	173.76
16PM02	10-Dec-03	17.2	173.88
16PM02	11-Dec-03	17.18	173.9
16PM02	12-Dec-03	17.18	173.9
16PM02	9-Feb-04	17.31	173.77
16PM02	12-Feb-04	17.51	173.57
16PM02	13-Feb-04	17.48	173.6
16PM02	14-Feb-04	17.36	173.72
16PM02	15-Feb-04	17.46	173.62
16PM02	16-Feb-04	17.45	173.63
16PM02	17-Feb-04	17.43	173.65
16PM02	18-Feb-04	17.38	173.7
16PM02	19-Feb-04	17.25	173.83
16PM02	20-Feb-04	17.26	173.82
16PM02	23-Feb-04	17.29	173.79
16PM02	25-Feb-04	17.25	173.83
16PM02	27-Feb-04	17.3	173.78
16PM02	5-Mar-04	17.03	174.05

Location	Date Sampled	Depth to Groundwater (ft bgs)	Groundwater Elevation (ft msl)
16WW16	28-Sep-04	21.76	173.9
16WW16	30-Nov-04	21.65	174.01
16WW16	25-Jan-05	20.69	174.97
16WW16	8-Mar-05	20.52	175.14
16WW16	24-May-05	20.55	175.11
16WW16	18-Oct-05	22.3	173.36
16WW16	1-Nov-05	22.4	173.26
16WW16	19-Dec-05	22.58	173.08
16WW16	30-Jan-06	22.7	172.96
16WW16	8-May-06	22.3	173.36
16WW16	20-Jun-06	22.73	172.93
16WW19	8-Dec-03	10.47	171.4
16WW19	10-Dec-03	10.42	171.45
16WW19	12-Dec-03	10.49	171.38
16WW19	11-Feb-04	9.54	172.33
16WW19	12-Feb-04	9.54	172.33
16WW19	12-Feb-04	9.52	172.35
16WW19	13-Feb-04	9.49	172.38
16WW19	14-Feb-04	9.4	172.47
16WW19	15-Feb-04	9.53	172.34
16WW19	17-Feb-04	9.24	172.63
16WW19	18-Feb-04	9.21	172.66
16WW19	19-Feb-04	9.14	172.73
16WW19	20-Feb-04	9.05	172.82
16WW19	23-Feb-04	34.38	147.49
16WW19	25-Feb-04	13.3	168.57
16WW19	27-Feb-04	9.9	171.97
16WW19	5-Mar-04	8.47	173.4
16WW19	9-Mar-04	8.34	173.53
16WW19	17-Mar-04	8.32	173.55
16WW19	24-Mar-04	8.33	173.54
16WW19	20-Apr-04	8.3	173.57
16WW19	18-May-04	8.2	173.67
16WW19	2-Jun-04	8.37	173.5
16WW19	14-Jun-04	7.56	174.31
16WW19	7-Jul-04	7.58	174.29
16WW19	3-Aug-04	8.65	173.22
16WW19	28-Sep-04	10	171.87
16WW19	30-Nov-04	8.7	173.17
16WW19	25-Jan-05	7.76	174.11
16WW19	8-Mar-05	7.51	174.36
16WW19	24-May-05	8.22	173.65
16WW19	18-Oct-05	10.6	171.27
16WW19	1-Nov-05	10.7	171.17
16WW19	19-Dec-05	10.45	171.42
16WW19	30-Jan-06	10.37	171.5
16WW19	8-May-06	9.39	172.48
16WW19	20-Jun-06	10.18	171.69

TABLE E-1: GROUNDWATER ELEVATION DATA.
Site 16 Landfill, LHAAP, Karnack, Texas

Location	Date Sampled	Depth to Groundwater (ft bgs)	Groundwater Elevation (ft msl)	Location	Date Sampled	Depth to Groundwater (ft bgs)	Groundwater Elevation (ft msl)
16PM02	9-Mar-04	16.96	174.12	16WW20	8-Dec-03	25.49	173.44
16PM02	17-Mar-04	16.87	174.21	16WW20	10-Dec-03	25.44	173.49
16PM02	22-Mar-04	17.84	173.24	16WW20	12-Dec-03	25.51	173.42
16PM02	24-Mar-04	16.83	174.25	16WW20	11-Feb-04	25.42	173.51
16PM02	20-Apr-04	16.63	174.45	16WW20	12-Feb-04	25.42	173.51
16PM02	4-May-04	16.6	174.48	16WW20	12-Feb-04	25.38	173.55
16PM02	18-May-04	16.57	174.51	16WW20	13-Feb-04	25.41	173.52
16PM02	2-Jun-04	16.61	174.47	16WW20	14-Feb-04	25.35	173.58
16PM02	14-Jun-04	16.45	174.63	16WW20	15-Feb-04	25.32	173.61
16PM02	3-Aug-04	16.3	174.78	16WW20	17-Feb-04	25.37	173.56
16PM02	28-Sep-04	17.1	173.98	16WW20	18-Feb-04	25.36	173.57
16PM02	30-Nov-04	16.95	174.13	16WW20	19-Feb-04	25.31	173.62
16PM02	25-Jan-05	16	175.08	16WW20	20-Feb-04	25.28	173.65
16PM02	8-Mar-05	15.83	175.25	16WW20	23-Feb-04	25.27	173.66
16PM02	24-May-05	15.91	175.17	16WW20	25-Feb-04	31.15	167.78
16PM02	18-Oct-05	17.55	173.53	16WW20	27-Feb-04	25.95	172.98
16PM02	1-Nov-05	17.81	173.27	16WW20	5-Mar-04	25.1	173.83
16PM02	19-Dec-05	17.86	173.22	16WW20	9-Mar-04	25.08	173.85
16PM02	30-Jan-06	17.95	173.13	16WW20	17-Mar-04	24.9	174.03
16PM02	14-Mar-06	17.95	173.13	16WW20	24-Mar-04	24.88	174.05
16PM02	8-May-06	17.59	173.49	16WW20	20-Apr-04	24.62	174.31
16PM02	20-Jun-06	18.05	173.03	16WW20	18-May-04	24.37	174.56
16PM03	1-Jul-03	15.205	175.24	16WW20	2-Jun-04	24.3	174.63
16PM03	2-Jul-03	15.2	175.24	16WW20	14-Jun-04	24.05	174.88
16PM03	8-Dec-03	16.61	173.83	16WW20	7-Jul-04	23.9	175.03
16PM03	8-Dec-03	16.58	173.86	16WW20	3-Aug-04	24.12	174.81
16PM03	8-Dec-03	16.59	173.85	16WW20	28-Sep-04	24.9	174.03
16PM03	9-Dec-03	16.49	173.95	16WW20	30-Nov-04	24.9	174.03
16PM03	9-Dec-03	16.61	173.83	16WW20	25-Jan-05	24.13	174.8
16PM03	10-Dec-03	16.57	173.87	16WW20	8-Mar-05	23.63	175.3
16PM03	10-Dec-03	16.64	173.8	16WW20	24-May-05	23.65	175.28
16PM03	11-Dec-03	16.63	173.81	16WW20	18-Oct-05	25.9	173.03
16PM03	12-Dec-03	16.64	173.8	16WW20	1-Nov-05	26	172.93
16PM03	9-Feb-04	16.77	173.67	16WW20	19-Dec-05	26.28	172.65
16PM03	12-Feb-04	16.92	173.52	16WW20	30-Jan-06	26.06	172.87
16PM03	13-Feb-04	16.88	173.56	16WW20	8-May-06	25.48	173.45
16PM03	14-Feb-04	16.77	173.67	16WW20	20-Jun-06	25.92	173.01
16PM03	15-Feb-04	16.86	173.58	16WW35	1-Jul-03	16.89	173.64
16PM03	16-Feb-04	16.845	173.6	16WW35	2-Jul-03	16.88	173.65
16PM03	17-Feb-04	16.83	173.61	16WW35	8-Dec-03	18.31	172.22
16PM03	18-Feb-04	16.785	173.66	16WW35	8-Dec-03	18.25	172.28
16PM03	19-Feb-04	16.66	173.78	16WW35	8-Dec-03	18.28	172.25
16PM03	20-Feb-04	16.7	173.74	16WW35	9-Dec-03	18.13	172.4
16PM03	23-Feb-04	16.72	173.72	16WW35	9-Dec-03	18.31	172.22
16PM03	25-Feb-04	16.64	173.8	16WW35	10-Dec-03	18.25	172.28
16PM03	27-Feb-04	16.7	173.74	16WW35	10-Dec-03	18.37	172.16
16PM03	5-Mar-04	16.46	173.98	16WW35	11-Dec-03	18.33	172.2
16PM03	9-Mar-04	16.4	174.04	16WW35	12-Dec-03	18.35	172.18

TABLE E-1: GROUNDWATER ELEVATION DATA.
Site 16 Landfill, LHAAP, Karnack, Texas

Location	Date Sampled	Depth to Groundwater (ft bgs)	Groundwater Elevation (ft msl)	Location	Date Sampled	Depth to Groundwater (ft bgs)	Groundwater Elevation (ft msl)
16PM03	17-Mar-04	6.3	184.14	16WW35	9-Feb-04	18.38	172.15
16PM03	22-Mar-04	16.26	174.18	16WW35	12-Feb-04	18.5	172.03
16PM03	24-Mar-04	16.26	174.18	16WW35	13-Feb-04	18.43	172.1
16PM03	20-Apr-04	16.09	174.35	16WW35	14-Feb-04	18.34	172.19
16PM03	4-May-04	16.05	174.39	16WW35	15-Feb-04	18.43	172.1
16PM03	18-May-04	16.01	174.43	16WW35	17-Feb-04	18.41	172.12
16PM03	2-Jun-04	16.05	174.39	16WW35	18-Feb-04	18.35	172.18
16PM03	14-Jun-04	15.91	174.53	16WW35	19-Feb-04	18.24	172.29
16PM03	3-Aug-04	15.73	174.71	16WW35	20-Feb-04	18.25	172.28
16PM03	28-Sep-04	16.7	173.74	16WW35	23-Feb-04	18.31	172.22
16PM03	30-Nov-04	16.41	174.03	16WW35	25-Feb-04	18.3	172.23
16PM03	25-Jan-05	15.5	174.94	16WW35	27-Feb-04	18.3	172.23
16PM03	8-Mar-05	15.3	175.14	16WW35	5-Mar-04	18.05	172.48
16PM03	24-May-05	15.32	175.12	16WW35	9-Mar-04	18	172.53
16PM03	18-Oct-05	17	173.44	16WW35	17-Mar-04	17.9	172.63
16PM03	1-Nov-05	17.02	173.42	16WW35	24-Mar-04	17.87	172.66
16PM03	19-Dec-05	17.35	173.09	16WW35	20-Apr-04	17.75	172.78
16PM03	30-Jan-06	17.44	173	16WW35	18-May-04	17.7	172.83
16PM03	14-Mar-06	17.39	173.05	16WW35	2-Jun-04	17.72	172.81
16PM03	8-May-06	17.08	173.36	16WW35	14-Jun-04	17.5	173.03
16PM03	20-Jun-06	17.5	172.94	16WW35	7-Jul-04	17.28	173.25
16PM04	1-Jul-03	15.19	175.2	16WW35	3-Aug-04	17.45	173.08
16PM04	1-Jul-03	15.22	175.17	16WW35	28-Sep-04	18.3	172.23
16PM04	1-Jul-03	15.17	175.22	16WW35	30-Nov-04	18.05	172.48
16PM04	2-Jul-03	15.165	175.23	16WW35	25-Jan-05	17.2	173.33
16PM04	8-Dec-03	16.6	173.79	16WW35	8-Mar-05	16.94	173.59
16PM04	8-Dec-03	16.6	173.79	16WW35	24-May-05	17.05	173.48
16PM04	8-Dec-03	16.54	173.85	16WW35	18-Oct-05	18.71	171.82
16PM04	9-Dec-03	16.44	173.95	16WW35	1-Nov-05	18.85	171.68
16PM04	9-Dec-03	16.57	173.82	16WW35	19-Dec-05	18.97	171.56
16PM04	10-Dec-03	16.53	173.86	16WW35	30-Jan-06	19.02	171.51
16PM04	10-Dec-03	16.5	173.89	16WW35	8-May-06	18.57	171.96
16PM04	11-Dec-03	16.59	173.8	16WW35	20-Jun-06	19.07	171.46
16PM04	12-Dec-03	16.6	173.79	16WW36	1-Jul-03	16.22	174.63
16PM04	9-Feb-04	16.73	173.66	16WW36	2-Jul-03	16.22	174.63
16PM04	12-Feb-04	16.86	173.53	16WW36	8-Dec-03	17.61	173.24
16PM04	13-Feb-04	16.82	173.57	16WW36	8-Dec-03	17.57	173.28
16PM04	18-Feb-04	16.73	173.66	16WW36	8-Dec-03	17.59	173.26
16PM04	19-Feb-04	16.61	173.78	16WW36	9-Dec-03	17.38	173.47
16PM04	20-Feb-04	16.61	173.78	16WW36	9-Dec-03	17.62	173.23
16PM04	23-Feb-04	16.69	173.7	16WW36	10-Dec-03	17.57	173.28
16PM04	25-Feb-04	16.6	173.79	16WW36	10-Dec-03	17.62	173.23
16PM04	27-Feb-04	16.65	173.74	16WW36	11-Dec-03	17.63	173.22
16PM04	5-Mar-04	16.38	174.01	16WW36	12-Dec-03	17.64	173.21
16PM04	9-Mar-04	16.34	174.05	16WW36	9-Feb-04	17.77	173.08
16PM04	17-Mar-04	16.25	174.14	16WW36	13-Feb-04	17.8	173.05
16PM04	22-Mar-04	16.22	174.17	16WW36	14-Feb-04	17.72	173.13
16PM04	24-Mar-04	16.22	174.17	16WW36	15-Feb-04	17.77	173.08

TABLE E-1: GROUNDWATER ELEVATION DATA.
Site 16 Landfill, LHAAP, Karnack, Texas

Location	Date Sampled	Depth to Groundwater (ft bgs)	Groundwater Elevation (ft msl)	Location	Date Sampled	Depth to Groundwater (ft bgs)	Groundwater Elevation (ft msl)
16PM04	20-Apr-04	16.06	174.33	16WW36	17-Feb-04	17.72	173.13
16PM04	4-May-04	16.05	174.34	16WW36	18-Feb-04	17.73	173.12
16PM04	18-May-04	15.98	174.41	16WW36	19-Feb-04	17.6	173.25
16PM04	2-Jun-04	16.02	174.37	16WW36	20-Feb-04	17.6	173.25
16PM04	14-Jun-04	15.92	174.47	16WW36	23-Feb-04	17.6	173.25
16PM04	7-Jul-04	15.6	174.79	16WW36	25-Feb-04	17.6	173.25
16PM04	3-Aug-04	15.7	174.69	16WW36	27-Feb-04	17.65	173.2
16PM04	28-Sep-04	16.5	173.89	16WW36	5-Mar-04	17.4	173.45
16PM04	30-Nov-04	16.71	173.68	16WW36	9-Mar-04	17.33	173.52
16PM04	25-Jan-05	15.45	174.94	16WW36	17-Mar-04	17.23	173.62
16PM04	8-Mar-05	15.26	175.13	16WW36	24-Mar-04	17.22	173.63
16PM04	24-May-05	15.3	175.09	16WW36	20-Apr-04	17.1	173.75
16PM04	18-Oct-05	16.3	174.09	16WW36	18-May-04	17.02	173.83
16PM04	1-Nov-05	17	173.39	16WW36	2-Jun-04	17.06	173.79
16PM04	19-Dec-05	17.3	173.09	16WW36	14-Jun-04	16.9	173.95
16PM04	30-Jan-06	17.4	172.99	16WW36	7-Jul-04	16.62	174.23
16PM04	15-Mar-06	17.37	173.02	16WW36	3-Aug-04	16.77	174.08
16PM04	8-May-06	16.99	173.4	16WW36	28-Sep-04	17.59	173.26
16PM04	20-Jun-06	17.43	172.96	16WW36	30-Nov-04	17.4	173.45
16PM05	1-Jul-03	13.82	175.13	16WW36	25-Jan-05	16.78	174.07
16PM05	1-Jul-03	13.84	175.11	16WW36	8-Mar-05	16.33	174.52
16PM05	1-Jul-03	13.63	175.32	16WW36	24-May-05	16.44	174.41
16PM05	1-Jul-03	13.62	175.33	16WW36	18-Oct-05	18.05	172.8
16PM05	2-Jul-03	13.62	175.33	16WW36	1-Nov-05	18.18	172.67
16PM05	8-Dec-03	15.02	173.93	16WW36	19-Dec-05	18.37	172.48
16PM05	8-Dec-03	14.98	173.97	16WW36	30-Jan-06	18.41	172.44
16PM05	8-Dec-03	14.99	173.96	16WW36	8-May-06	17.98	172.87
16PM05	9-Dec-03	14.52	174.43	16WW36	20-Jun-06	18.46	172.39
16PM05	9-Dec-03	15.02	173.93	16WW37	8-Dec-03	27.75	173.96
16PM05	10-Dec-03	15.04	173.91	16WW37	10-Dec-03	27.78	173.93
16PM05	10-Dec-03	14.59	174.36	16WW37	12-Dec-03	27.79	173.92
16PM05	11-Dec-03	15.06	173.89	16WW37	11-Feb-04	27.95	173.76
16PM05	12-Dec-03	15.03	173.92	16WW37	12-Feb-04	27.95	173.76
16PM05	12-Dec-03	15.05	173.9	16WW37	12-Feb-04	28.03	173.68
16PM05	9-Feb-04	15.19	173.76	16WW37	13-Feb-04	27.97	173.74
16PM05	12-Feb-04	15.07	173.88	16WW37	14-Feb-04	27.89	173.82
16PM05	13-Feb-04	15.04	173.91	16WW37	15-Feb-04	27.96	173.75
16PM05	18-Feb-04	14.98	173.97	16WW37	17-Feb-04	27.95	173.76
16PM05	19-Feb-04	14.83	174.12	16WW37	18-Feb-04	27.89	173.82
16PM05	20-Feb-04	14.85	174.1	16WW37	19-Feb-04	27.77	173.94
16PM05	23-Feb-04	14.86	174.09	16WW37	20-Feb-04	27.76	173.95
16PM05	25-Feb-04	14.9	174.05	16WW37	23-Feb-04	27.77	173.94
16PM05	27-Feb-04	14.9	174.05	16WW37	25-Feb-04	27.75	173.96
16PM05	5-Mar-04	14.6	174.35	16WW37	27-Feb-04	27.8	173.91
16PM05	9-Mar-04	14.6	174.35	16WW37	5-Mar-04	27.53	174.18
16PM05	17-Mar-04	14.5	174.45	16WW37	9-Mar-04	27.51	174.2
16PM05	22-Mar-04	14.51	174.44	16WW37	17-Mar-04	27.4	174.31
16PM05	24-Mar-04	14.62	174.33	16WW37	24-Mar-04	27.32	174.39

TABLE E-1: GROUNDWATER ELEVATION DATA.
Site 16 Landfill, LHAAP, Karnack, Texas

Location	Date Sampled	Depth to Groundwater (ft bgs)	Groundwater Elevation (ft msl)	Location	Date Sampled	Depth to Groundwater (ft bgs)	Groundwater Elevation (ft msl)
16PM05	20-Apr-04	14.5	174.45	16WW37	20-Apr-04	27.22	174.49
16PM05	4-May-04	14.45	174.5	16WW37	18-May-04	27.13	174.58
16PM05	18-May-04	14.45	174.5	16WW37	2-Jun-04	27.2	174.51
16PM05	2-Jun-04	14.53	174.42	16WW37	14-Jun-04	27.05	174.66
16PM05	14-Jun-04	14.32	174.63	16WW37	7-Jul-04	26.75	174.96
16PM05	7-Jul-04	14.05	174.9	16WW37	3-Aug-04	26.87	174.84
16PM05	3-Aug-04	14.17	174.78	16WW37	28-Sep-04	27.7	174.01
16PM05	28-Sep-04	15	173.95	16WW37	30-Nov-04	27.57	174.14
16PM05	30-Nov-04	14.8	174.15	16WW37	25-Jan-05	26.61	175.1
16PM05	25-Jan-05	13.95	175	16WW37	8-Mar-05	26.45	175.26
16PM05	8-Mar-05	13.7	175.25	16WW37	24-May-05	26.3	175.41
16PM05	24-May-05	13.77	175.18	16WW37	18-Oct-05	28.2	173.51
16PM05	18-Oct-05	15.5	173.45	16WW37	1-Nov-05	28.33	173.38
16PM05	1-Nov-05	15.75	173.2	16WW37	19-Dec-05	28.54	173.17
16PM05	19-Dec-05	15.8	173.15	16WW37	30-Jan-06	28.65	173.06
16PM05	30-Jan-06	15.87	173.08	16WW37	8-May-06	28.25	173.46
16PM05	15-Mar-06	15.88	173.07	16WW37	20-Jun-06	28.7	173.01
16PM05	8-May-06	15.45	173.5	16WW38	8-Dec-03	27.61	174.07
16PM05	20-Jun-06	15.92	173.03	16WW38	10-Dec-03	27.63	174.05
16PM06	1-Jul-03	14.4	175.17	16WW38	12-Dec-03	27.69	173.99
16PM06	1-Jul-03	14.47	175.1	16WW38	12-Feb-04	27.88	173.8
16PM06	1-Jul-03	14.47	175.1	16WW38	13-Feb-04	27.82	173.86
16PM06	1-Jul-03	14.37	175.2	16WW38	14-Feb-04	27.73	173.95
16PM06	2-Jul-03	14.355	175.22	16WW38	15-Feb-04	27.81	173.87
16PM06	8-Dec-03	15.75	173.82	16WW38	17-Feb-04	27.79	173.89
16PM06	8-Dec-03	15.71	173.86	16WW38	18-Feb-04	27.74	173.94
16PM06	8-Dec-03	15.73	173.84	16WW38	19-Feb-04	27.61	174.07
16PM06	9-Dec-03	15.32	174.25	16WW38	20-Feb-04	27.61	174.07
16PM06	9-Dec-03	15.75	173.82	16WW38	23-Feb-04	27.6	174.08
16PM06	10-Dec-03	15.75	173.82	16WW38	25-Feb-04	27.6	174.08
16PM06	10-Dec-03	15.49	174.08	16WW38	27-Feb-04	27.65	174.03
16PM06	11-Dec-03	15.79	173.78	16WW38	5-Mar-04	27.36	174.32
16PM06	12-Dec-03	15.765	173.81	16WW38	9-Mar-04	27.34	174.34
16PM06	12-Dec-03	15.79	173.78	16WW38	17-Mar-04	27.25	174.43
16PM06	9-Feb-04	15.94	173.63	16WW38	24-Mar-04	27.14	174.54
16PM06	12-Feb-04	15.89	173.68	16WW38	20-Apr-04	27.05	174.63
16PM06	13-Feb-04	15.88	173.69	16WW38	18-May-04	27.98	173.7
16PM06	18-Feb-04	15.81	173.76	16WW38	2-Jun-04	27.02	174.66
16PM06	19-Feb-04	15.41	174.16	16WW38	14-Jun-04	26.9	174.78
16PM06	20-Feb-04	15.71	173.86	16WW38	7-Jul-04	26.6	175.08
16PM06	23-Feb-04	15.76	173.81	16WW38	3-Aug-04	26.72	174.96
16PM06	25-Feb-04	15.75	173.82	16WW38	28-Sep-04	27.55	174.13
16PM06	27-Feb-04	15.75	173.82	16WW38	30-Nov-04	27.42	174.26
16PM06	5-Mar-04	15.5	174.07	16WW38	25-Jan-05	26.47	175.21
16PM06	9-Mar-04	15.96	173.61	16WW38	8-Mar-05	26.27	175.41
16PM06	17-Mar-04	15.36	174.21	16WW38	24-May-05	26.48	175.2
16PM06	22-Mar-04	15.34	174.23	16WW38	18-Oct-05	28.08	173.6
16PM06	24-Mar-04	15.38	174.19	16WW38	1-Nov-05	28.18	173.5

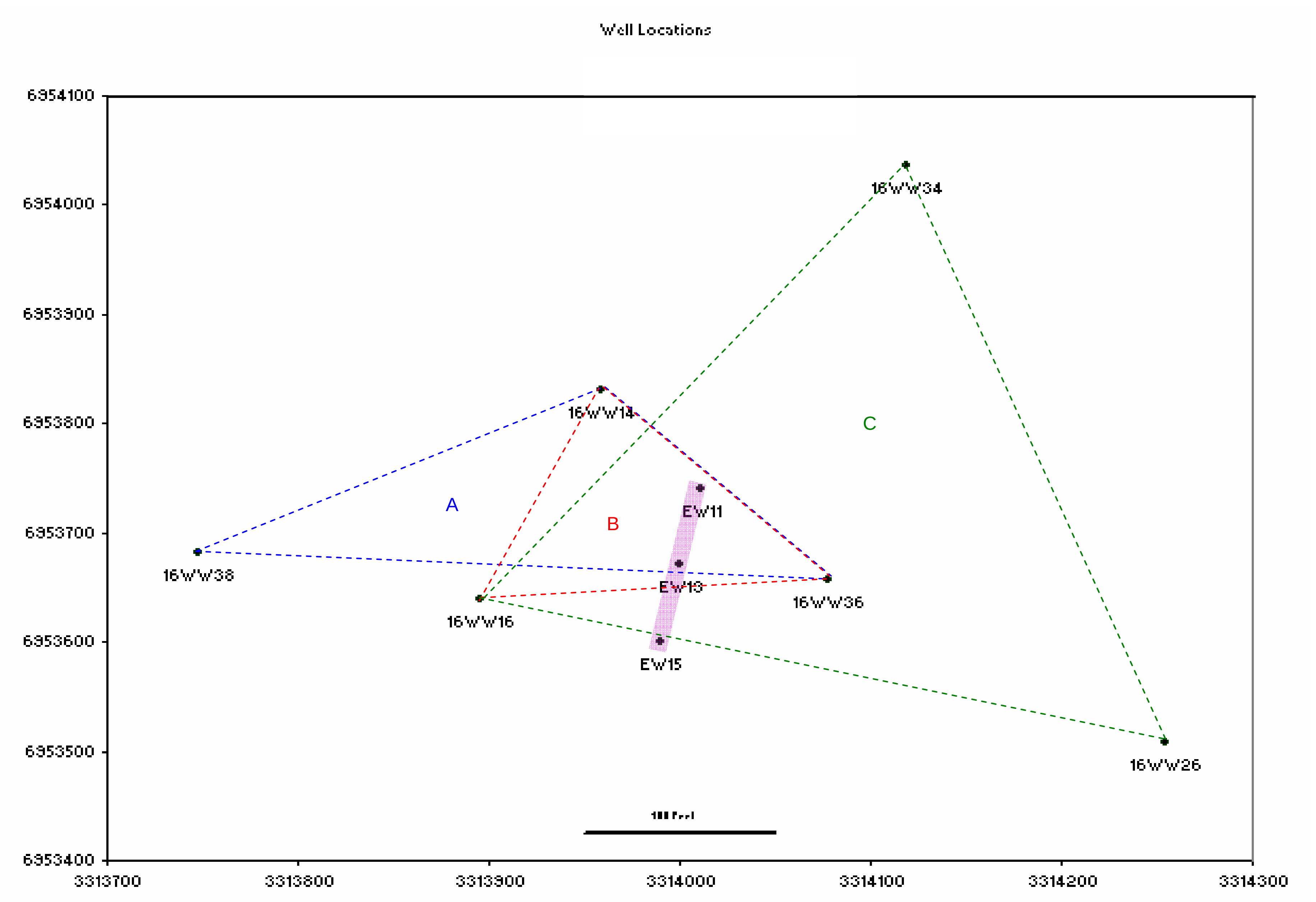
TABLE E-1: GROUNDWATER ELEVATION DATA.
Site 16 Landfill, LHAAP, Karnack, Texas

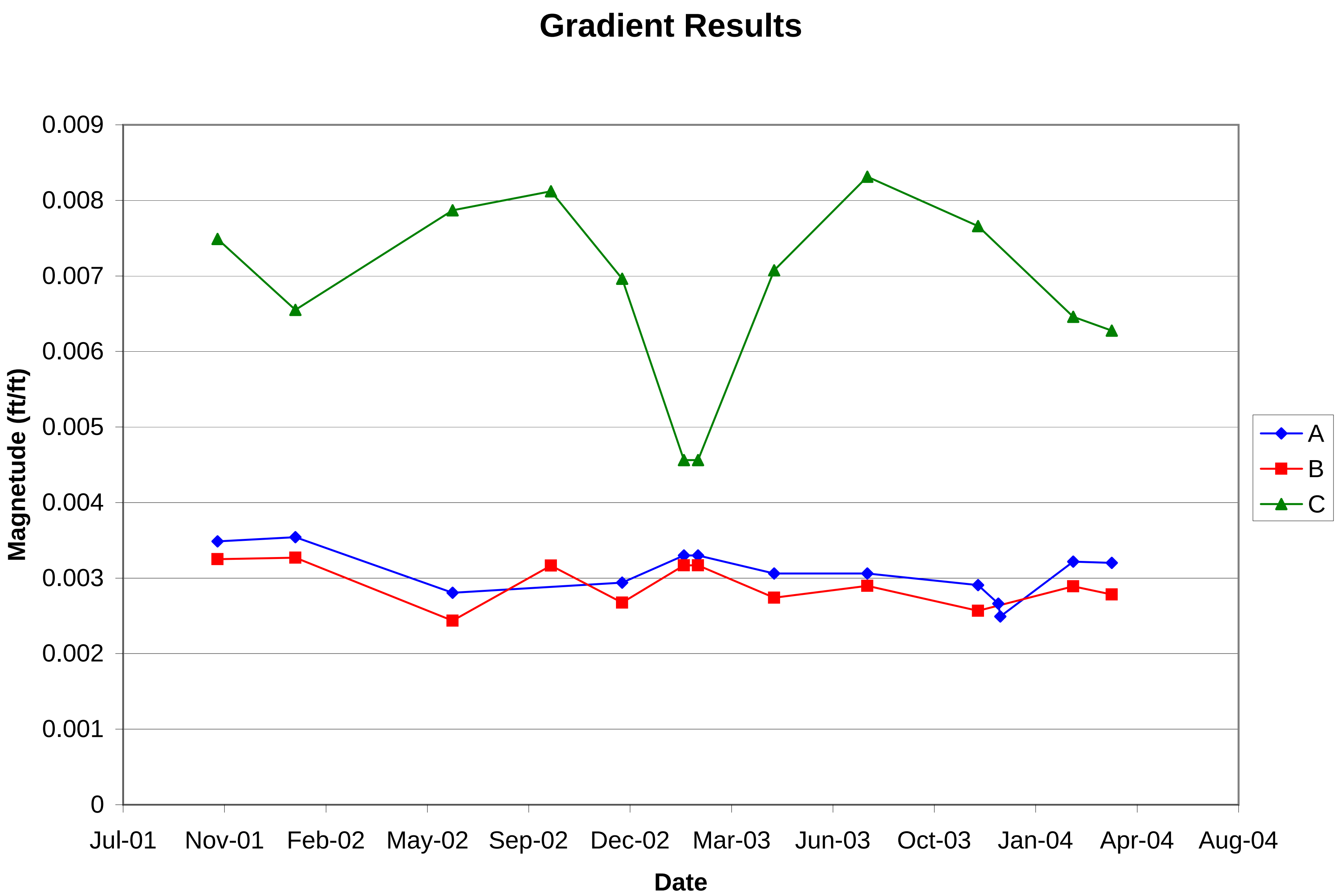
Location	Date Sampled	Depth to Groundwater (ft bgs)	Groundwater Elevation (ft msl)
16PM06	20-Apr-04	15.28	174.29
16PM06	4-May-04	15.2	174.37
16PM06	18-May-04	15.21	174.36
16PM06	2-Jun-04	15.27	174.3
16PM06	14-Jun-04	15.1	174.47

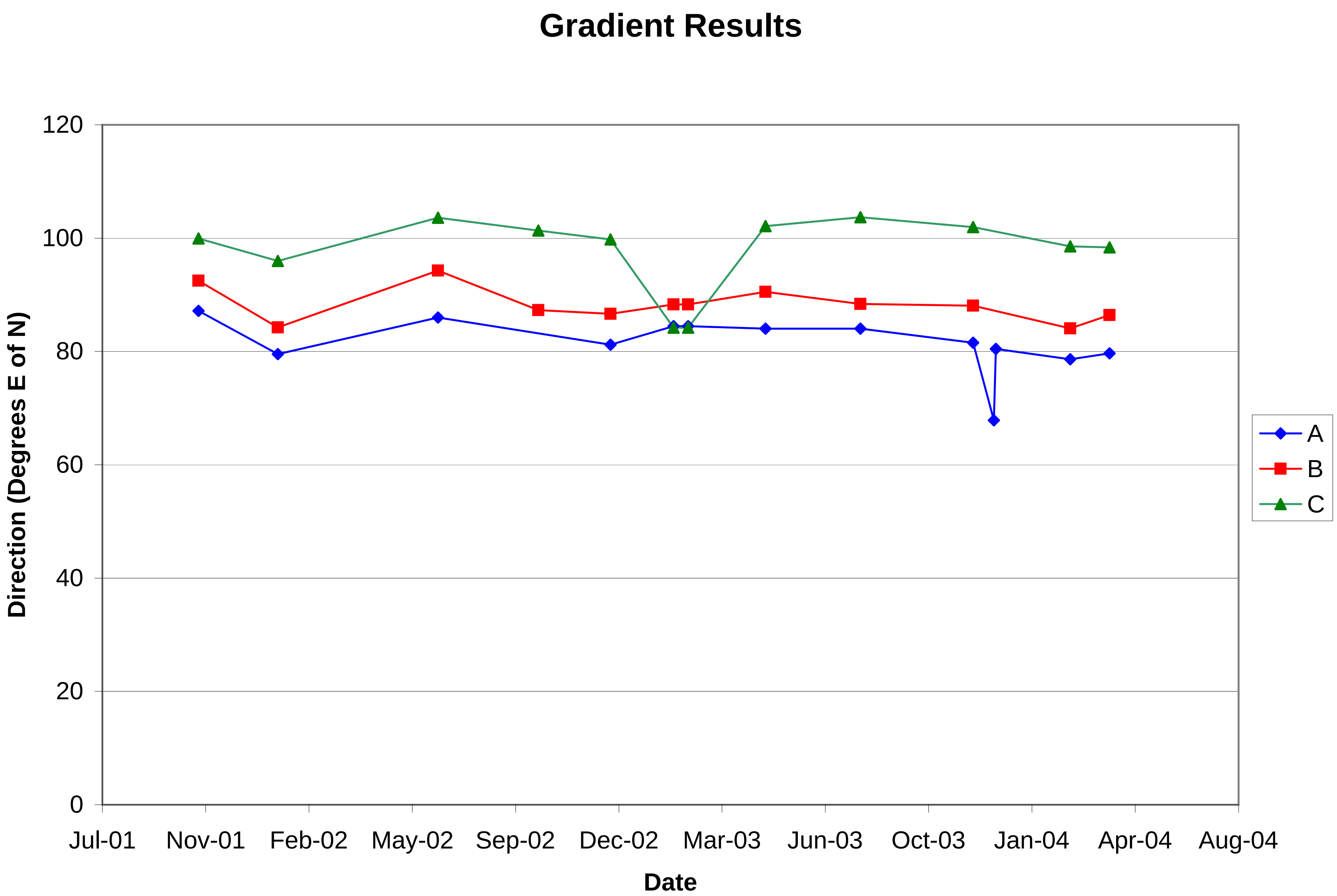
Location	Date Sampled	Depth to Groundwater (ft bgs)	Groundwater Elevation (ft msl)
16WW38	19-Dec-05	28.39	173.29
16WW38	30-Jan-06	28.51	173.17
16WW38	8-May-06	28.12	173.56
16WW38	20-Jun-06	28.57	173.11

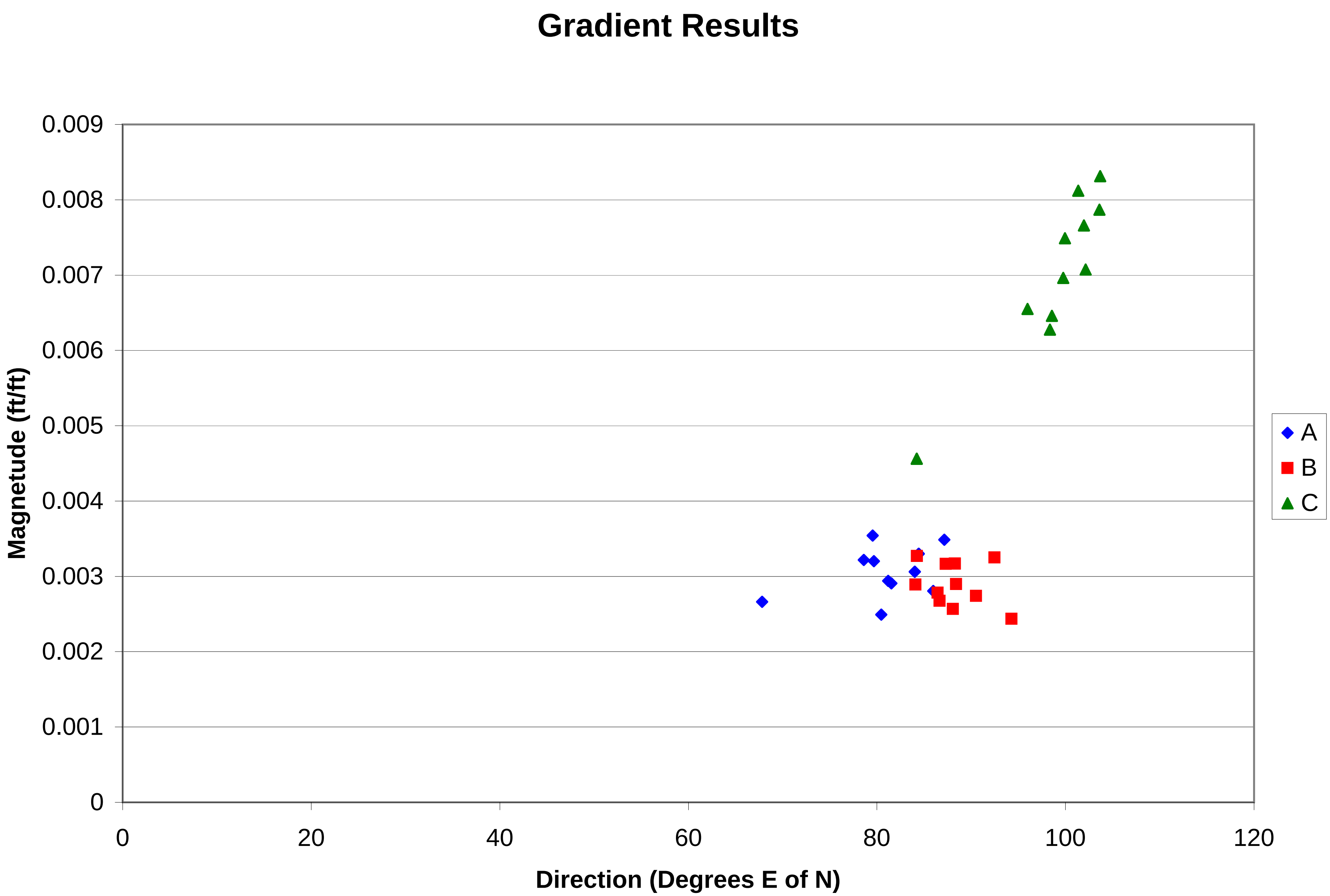
APPENDIX E
WATER LEVEL DATA AND ANALYSIS

Water elevation data collected from the site between October 2001 and April 2004 was used to evaluate the direction and magnitude of the water level gradient over time. Three-point gradients from three “triangles” of wells were calculated and analyzed in for magnitude and direction over time. The three triangles selected were referred to as A (16WW14, 16WW36, and 16WW38); B (16WW14, 16WW16, and 16WW36); and C (16WW16, 16WW34, and 16WW26). The triangle locations were selected to cover the demonstration test area and the specific wells were selected on the basis of similar construction details (i.e. screen depths). Magnitudes were found to vary between from 0.002 to 0.008 ft/ft and direction varied 78 to 103 degrees East of North.


Well Locations
6954100
6954000
6953900
6953800
6953700
6953600
6953500
6953400
3313700
3313800
3313900
3314000
3314100
3314200
3314300
16WW34
16WW14
16WW38
16WW16
16WW36
16WW26
EW11
EW13
EW15
A
B
C


Gradient Results
Magnetude (ft/ft)
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
Jul-01
Nov-01
Feb-02
May-02
Sep-02
Dec-02
Mar-03
Jun-03
Oct-03
Jan-04
Apr-04
Aug-04
Date
A
B
C


Gradient Results
Direction (Degrees E of N)
120
100
80
60
40
20
0
Jul-01
Nov-01
Feb-02
May-02
Sep-02
Dec-02
Mar-03
Jun-03
Oct-03
Jan-04
Apr-04
Aug-04
Date
A
B
C



Gradient Results
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
0
20
40
60
80
100
120
Magnetude (ft/ft)
Direction (Degrees E of N)
A
B
C

APPENDIX F

GROUNDWATER CHEMISTRY DATA

TABLE F-1: RESULTS OF FIELD PARAMETER ANALYSIS.
Site 16 Landfill, LHAAP, Karnack, Texas

Location	Date Sampled	Dissolved Oxygen (mg/L)	ORP (mV)	pH (std. units)	Specific Conductance (µS/cm)	Temperature (ºC)
16EW09	24-Mar-04	1.43	108	5.87	9,730	18.4
	07-Apr-04	1.58	74.3	6.06	7,230	24.1
	21-Apr-04	0.310	89.7	5.86	10,600	24.5
	05-May-04	0.430	62.9	5.91	8,950	20.1
	20-May-04	0.630	67.8	5.92	6,490	19.0
	04-Jun-04	1.23	84.6	5.96	7,370	19.2
	17-Jun-04	1.16	65.6	5.99	7,410	19.8
	05-Aug-04	1.42	94.3	5.80	7,650	19.8
	29-Sep-04	1.67	72.7	6.04	6,560	19.8
	02-Dec-04	0.820	137	5.98	5,890	18.7
	26-Jan-05	0.420	107	6.15	5,040	21.1
	09-Mar-05		104	6.20	3,440	18.1
	25-May-05		76.4	5.95	5,660	18.7
	19-Oct-05	3.69	60.4	6.07	7,810	19.2
	03-Nov-05	11.8	89.0	5.98	8,270	19.2
	19-Dec-05	0.800	98.6	5.39	4,250	19.9
	30-Jan-06	2.09	65.2	5.97	7,490	21.4
	15-Mar-06		60.0	5.75	10,200	19.7
	09-May-06	5.17	99.1	5.67	7,990	20.3
	22-Jun-06		94.2			
16EW10	23-Mar-04	1.42		6.09	6,020	18.9
	07-Apr-04	2.61	54.2	6.26	5,990	23.5
	21-Apr-04	2.09	49.5	6.17	5,700	24.8
	05-May-04	0.120	29.6	6.08	5,720	19.6
	20-May-04	0.560	44.4	6.14	4,990	19.5
	04-Jun-04	0.960	56.9	6.07	4,890	19.7
	18-Jun-04	1.60	51.5	5.98	5,220	20.0
	08-Jul-04	0.760	76.7	6.13	5,220	20.0
	05-Aug-04	3.71	66.4	6.08	5,180	22.1
	29-Sep-04	0.800	38.3	6.47	4,840	29.0
	02-Dec-04	0.440	61.7	6.10	4,630	18.3
	26-Jan-05	1.21	79.1	6.23	4,230	20.4
	09-Mar-05		60.7	7.09	5,520	18.3
	25-May-05		-224	6.12	6,620	19.8
	19-Oct-05	2.51	2.50	6.57	6,430	19.4
	02-Nov-05	2.93	53.7	6.65	5,670	20.5
	19-Dec-05	0.600	35.9	5.98	3,620	17.8
	30-Jan-06	0.450	70.6	6.27	5,800	21.7
	15-Mar-06		20.0	6.11	6,380	19.7
	09-May-06	7.54	46.6	6.13	5,110	21.0
	22-Jun-06		-14.4			

TABLE F-1: RESULTS OF FIELD PARAMETER ANALYSIS.
Site 16 Landfill, LHAAP, Karnack, Texas

Location	Date Sampled	Dissolved Oxygen (mg/L)	ORP (mV)	pH (std. units)	Specific Conductance (µS/cm)	Temperature (ºC)
16EW12B	24-Mar-04	1.68	223	6.39	7,040	19.2
	07-Apr-04	2.50	387		5,910	
	21-Apr-04	0.670	456	6.35	7,910	25.7
	05-May-04	0.180	-20.5	6.40	6,330	19.1
	20-May-04	0.150	-32.3	6.23	4,950	19.3
	04-Jun-04	0.630	-34.5	6.28	4,780	18.7
	18-Jun-04	1.10	-53.2	6.30	4,640	19.3
	08-Jul-04	0.660	-19.3	6.50	4,280	20.0
	05-Aug-04	1.42	-29.5	6.48	4,010	19.7
	29-Sep-04	0.680	-34.3	6.48	1,890	20.1
	02-Dec-04	0.980	12.1	6.46	3,380	18.6
	26-Jan-05	2.69	-57.4	6.36	4,570	19.7
	09-Mar-05		-199	6.86	5,340	19.3
	25-May-05		-236	6.48	5,590	19.5
	19-Oct-05	1.89	-51.1	6.58	5,100	19.5
	03-Nov-05	29.4	-7.70	6.60	8,190	18.7
	19-Dec-05	3.37	-265	6.08	10,400	19.7
	30-Jan-06	6.62	-311	6.63	9,010	21.8
	16-Mar-06		-324	6.70	10,100	18.7
	09-May-06	8.90	-322	6.62	10,700	20.3
	22-Jun-06		-297			
16EW14B	24-Mar-04	1.80	206	6.18	8,990	19.7
	07-Apr-04	0.870	61.0	6.34	9,100	20.1
	21-Apr-04	0.0700	-50.4	6.04	10,300	25.7
	05-May-04	0.190	-182	6.24	7,560	19.3
	20-May-04	ND	-99.3	6.23	6,050	19.4
	04-Jun-04	0.660	-34.7	6.23	5,680	19.2
	17-Jun-04	0.390	-96.4	6.30	5,470	20.4
	08-Jul-04	0.250	-100	6.32	4,840	20.8
	05-Aug-04	1.55	-20.8	6.09	3,870	20.1
	29-Sep-04	0.940	-6.40	6.10	4,550	19.8
	02-Dec-04	1.88	35.0	6.13	3,900	19.2
	26-Jan-05	0.730	-25.9	6.43	4,480	21.2
	09-Mar-05		-178	6.97	4,570	19.5
	25-May-05		-87.5	6.16	4,390	19.6
16PM01	23-Mar-04	0.620	8.00	6.13	1,480	17.6
	06-Apr-04	1.67	19.0	6.31	1,800	21.2
	20-Apr-04	1.05	36.6	6.24	1,910	25.6
	04-May-04	0.570	26.5	6.24	1,900	18.0
	18-May-04	1.32	21.3	6.28	1,690	18.8
	02-Jun-04	2.36	13.2	6.24	1,910	19.1
	16-Jun-04	2.64	15.3	6.25	1,860	18.7
	04-Aug-04	1.85	21.3	6.19	1,650	19.0
	28-Sep-04	2.80	53.5	6.32	1,400	19.2
	01-Dec-04	3.28	59.3	6.21	1,130	18.1
	26-Jan-05	6.06	85.6	6.27	1,630	18.2
	10-Mar-05		10.6	6.24	1,490	18.1
	24-May-05		9.20	6.23	1,830	18.7
	18-Oct-05		14.5	6.08	22,500	19.2

TABLE F-1: RESULTS OF FIELD PARAMETER ANALYSIS.
Site 16 Landfill, LHAAP, Karnack, Texas

Location	Date Sampled	Dissolved Oxygen (mg/L)	ORP (mV)	pH (std. units)	Specific Conductance (µS/cm)	Temperature (ºC)
16PM01	02-Nov-05	2.93	28.8	6.25	1,720	19.0
Cont.	20-Dec-05	23.8	44.2	8.12	1,870	15.3
	31-Jan-06	3.99	2.30	6.23	2,170	18.3
	14-Mar-06			6.54	2,380	18.6
	09-May-06	2.15	51.4	6.04	2,370	18.5
	20-Jun-06		43.5			
16PM02	23-Mar-04	2.78	84.0	5.62	1,360	18.2
	06-Apr-04	1.51	122	5.72	1,640	21.5
	20-Apr-04	1.08	151	5.58	1,730	23.5
	04-May-04	1.09	156	5.62	1,670	18.3
	18-May-04	0.670	147	5.61	1,480	19.4
	02-Jun-04	2.66	144	5.49	1,780	19.7
	16-Jun-04	2.89	153	5.53	1,750	19.0
	04-Aug-04	1.66	147	5.54	3,340	19.6
	28-Sep-04	2.27	175	5.53	1,380	19.7
	01-Dec-04	3.06	170	5.48	1,110	19.0
	26-Jan-05	3.62	166	5.57	1,770	18.7
	10-Mar-05		121	5.60	1,380	18.4
	24-May-05		135	5.58	2,090	18.9
	18-Oct-05		141	5.39	2,550	21.1
	02-Nov-05	3.08	145	5.58	2,480	19.2
	20-Dec-05	29.2	139	5.35	1,650	19.4
	31-Jan-06	3.87	112	5.62	2,050	19.2
	14-Mar-06			5.82	2,180	19.3
	09-May-06	4.08	144	5.36	1,910	19.1
	20-Jun-06		118			
16PM03	23-Mar-04	1.86	643	6.33	3,290	17.8
	06-Apr-04	2.18	88.0	6.45	3,370	21.3
	20-Apr-04	3.98	115	6.38	3,490	23.8
	04-May-04	0.940	125	6.34	3,450	17.8
	18-May-04	0.630	127	6.33	3,260	18.6
	02-Jun-04	2.66	129	6.33	3,350	19.1
	16-Jun-04	3.68	160	6.34	3,260	18.6
	04-Aug-04	1.88	209	6.38	2,960	20.2
	28-Sep-04	3.75	111	6.40	1,880	19.6
	01-Dec-04	2.91	117	6.29	1,470	18.2
	26-Jan-05	3.92	120	6.39	2,710	18.0
	10-Mar-05		65.5	6.44	2,960	17.4
	24-May-05		98.9	6.47	2,870	18.5
	18-Oct-05		101	6.45	2,480	19.7
	02-Nov-05	2.40	132	6.45	2,950	18.8
	20-Dec-05	24.0	94.1	6.79	7,040	15.2
	31-Jan-06	4.99	30.0	6.26	5,230	18.3
	14-Mar-06			6.51	4,300	19.4
	09-May-06	1.85	124	6.13	3,970	18.9
	20-Jun-06		112			
16PM04	23-Mar-04	1.54	417	6.12	4,530	18.1
	06-Apr-04	1.36	121	6.24	5,470	22.3
	20-Apr-04	1.27		6.13	5,500	23.0
	04-May-04	0.890	114	6.18	4,830	18.5
	18-May-04	0.280	72.6	6.22	3,930	19.2
	03-Jun-04	0.850	65.1	6.08	3,760	18.5

TABLE F-1: RESULTS OF FIELD PARAMETER ANALYSIS.
Site 16 Landfill, LHAAP, Karnack, Texas

Location	Date Sampled	Dissolved Oxygen (mg/L)	ORP (mV)	pH (std. units)	Specific Conductance (µS/cm)	Temperature (ºC)
16PM04 Cont.	16-Jun-04	1.73	51.0	6.15	3,640	19.0
	07-Jul-04	1.79	55.4	6.06	3,840	19.2
	04-Aug-04	1.57	54.0	6.30	3,730	20.2
	28-Sep-04	2.58	120	6.26	3,080	19.6
	01-Dec-04	3.15	69.6	6.21	1,550	18.5
	26-Jan-05	1.26	76.8	6.19	3,080	19.2
	10-Mar-05		31.2	6.17	3,560	18.1
	24-May-05		61.6	6.21	3,360	18.8
	18-Oct-05		78.1	6.12	3,960	20.3
	02-Nov-05	2.65	7.38	6.36	3,220	19.9
	20-Dec-05	4.65	-73.8	5.90	7,690	19.5
	30-Jan-06	1.24	-34.8	6.24	4,940	19.4
	15-Mar-06		-111	6.13	4,630	18.2
	08-May-06	4.07	-43.2	6.08	4,500	19.5
	20-Jun-06		-43.4			
16PM05	24-Mar-04	2.56	216	6.00	7,560	18.4
	06-Apr-04	0.110	129	6.30	8,310	23.2
	20-Apr-04	0.900	-1.80	6.03	8,280	23.8
	04-May-04	0.890	18.1	5.92	7,810	19.1
	18-May-04	1.04	32.5	5.90	6,990	19.5
	02-Jun-04	1.82	47.8	5.80	7,280	19.6
	16-Jun-04	2.32	70.3	5.83	6,800	19.6
	08-Jul-04	2.51	92.7	5.94	6,620	20.3
	04-Aug-04	1.90	87.0	6.00	6,130	20.4
	29-Sep-04	2.59	109	5.89	5,810	20.7
	01-Dec-04	3.55	122	5.86	5,300	20.5
	26-Jan-05	ND	28.9	6.29	4,770	20.5
	09-Mar-05		-21.7	6.86	6,120	18.3
	24-May-05		-46.4	6.35	5,440	19.0
	18-Oct-05		-27.3	6.27	7,730	22.0
	02-Nov-05	3.41	-17.5	6.36	7,160	21.0
	20-Dec-05	2.61	0.100	6.13	7,480	20.2
	30-Jan-06	1.63	-35.8	6.39	7,220	20.5
	15-Mar-06		-37.0	6.36	6,320	18.5
	08-May-06	2.41	-22.2	6.31	5,770	19.7
	20-Jun-06		-26.4			
16PM06	23-Mar-04	2.15		6.18	8,480	18.7
	06-Apr-04	3.63	24.0	6.42	8,650	21.8
	20-Apr-04	4.97	-19.5	6.21	8,330	24.6
	04-May-04	2.23	-33.0	6.37	8,340	19.3
	19-May-04	3.25	-62.2	6.49	7,000	19.0
	02-Jun-04	2.05	-47.7	6.19	6,830	20.0
	16-Jun-04	4.88	-50.4	6.33	6,200	20.2
	07-Jul-04	3.66	-7.70	6.14	5,480	20.2
	04-Aug-04	4.73	17.8	6.10	5,270	19.9
	28-Sep-04	5.31	47.3	6.06	4,310	20.4
	01-Dec-04	5.00	55.4	6.11	1,780	18.8
	26-Jan-05	1.49	6.50	6.49	3,980	20.3
	09-Mar-05		-6.20	6.85	4,750	17.8
	24-May-05		-48.5	6.41	4,150	19.0
	18-Oct-05		3.10	6.20	4,410	21.2
	02-Nov-05	9.20	-7.30	6.60	2,800	19.5

TABLE F-1: RESULTS OF FIELD PARAMETER ANALYSIS.
Site 16 Landfill, LHAAP, Karnack, Texas

Location	Date Sampled	Dissolved Oxygen (mg/L)	ORP (mV)	pH (std. units)	Specific Conductance (µS/cm)	Temperature (ºC)
16PM06 Cont.	20-Dec-05	4.01	1.10	6.08	4,980	19.5
	30-Jan-06	2.88	-30.2	6.31	4,970	19.5
	14-Mar-06		-7.10	6.64	4,650	18.4
	08-May-06	3.59	-16.3	6.32	4,030	19.5
	20-Jun-06		5.40			
16PM07-D	23-Mar-04	1.26		6.11	3,690	18.7
	07-Apr-04	1.20	94.9	6.24	3,680	25.0
	20-Apr-04	0.700	81.1	6.08	3,550	24.0
	04-May-04	1.47	78.7	6.19	3,490	18.9
	19-May-04	0.740	69.6	6.17	3,200	19.9
	03-Jun-04	0.400	84.0	6.06	3,260	18.9
	16-Jun-04	2.17	78.2	6.11	3,260	19.1
	07-Jul-04	2.01	89.1	6.05	3,480	19.6
	04-Aug-04	1.20	74.4	6.04	3,480	20.1
	28-Sep-04	2.40	95.4	6.09	3,300	19.7
	01-Dec-04	1.86	70.6	6.00	1,600	18.9
	26-Jan-05	1.10	96.9	6.28	3,550	18.9
	09-Mar-05		65.3	6.92	4,320	18.5
	24-May-05		52.4	5.93	4,010	19.6
	18-Oct-05		58.6	5.81	5,750	20.1
	02-Nov-05	3.66	71.2	6.11	4,530	19.7
	19-Dec-05	0.580	48.3	5.68	2,000	18.9
	30-Jan-06	2.14	-3.20	6.24	4,900	19.4
	14-Mar-06		-0.700	6.46	4,800	19.1
	08-May-06	2.68	17.0	6.09	4,420	19.6
	22-Jun-06		38.4			
16PM07-S	23-Mar-04	1.50		6.09	3,500	17.8
	06-Apr-04	1.99	125	7.05	3,640	21.9
	20-Apr-04	2.46	107	6.12	3,650	23.9
	04-May-04	1.67	121	6.18	3,800	18.0
	19-May-04	0.960	121	6.10	3,570	18.7
	03-Jun-04	2.50	111	6.08	3,460	18.6
	16-Jun-04	2.56	95.7	6.07	3,410	19.1
	07-Jul-04	2.90	94.5	6.03	3,440	19.8
	04-Aug-04	6.09	79.6	6.06	3,280	21.3
	28-Sep-04	7.43	118	6.16	1,950	21.3
	01-Dec-04	3.33	249	6.08	1,510	19.6
	26-Jan-05	2.02	150	6.26	2,970	18.5
	09-Mar-05		95.7	6.84	3,720	17.6
	24-May-05		61.8	6.11	3,480	19.2
	18-Oct-05		30.4	6.02	4,640	21.8
	02-Nov-05	4.93	72.7	6.48	3,750	21.0
	19-Dec-05	1.16	24.8	5.73	3,110	18.7
	30-Jan-06	2.63	-62.8	6.47	2,320	19.1
	14-Mar-06		-8.90	6.42	5,490	18.2
	08-May-06	3.26	19.7	5.87	4,970	19.8
	22-Jun-06		55.9			
16PM08	23-Mar-04	1.25	132	6.25	3,700	18.0
	07-Apr-04	1.76	158	6.37	4,530	25.0
	21-Apr-04	0.490	234	6.22	4,710	22.5
	05-May-04	1.30	203	6.31	4,580	17.9
	19-May-04	1.08	181	6.31	4,160	18.5

TABLE F-1: RESULTS OF FIELD PARAMETER ANALYSIS.
Site 16 Landfill, LHAAP, Karnack, Texas

Location	Date Sampled	Dissolved Oxygen (mg/L)	ORP (mV)	pH (std. units)	Specific Conductance (µS/cm)	Temperature (ºC)
16PM08 Cont.	03-Jun-04	1.35	192	6.27	4,290	18.7
	16-Jun-04	2.46	102	6.25	4,020	18.6
	08-Jul-04	2.11	235	6.32	4,030	19.6
	04-Aug-04	2.39	103	6.24	3,800	19.4
	28-Sep-04	2.58	179	6.31	3,400	20.4
	01-Dec-04	3.06	96.1	6.27	1,640	19.4
	26-Jan-05	4.12	148	6.30	3,260	18.2
	10-Mar-05		136	6.31	3,590	17.7
	24-May-05		126	6.30	3,410	18.7
	18-Oct-05		133	6.28	4,410	20.4
	02-Nov-05	4.70	74.1	6.64	6,780	19.7
	20-Dec-05	3.16	-14.5	6.05	9,460	19.2
	31-Jan-06	6.01	-85.3	6.33	8,940	18.6
	14-Mar-06			6.64	8,610	19.1
	09-May-06	3.24	-47.0	6.22	8,040	19.1
	22-Jun-06		-30.2			
16PM09	24-Mar-04	1.16	206	5.79	5,900	18.3
	06-Apr-04	1.26	136	6.10	6,200	22.5
	20-Apr-04	0.710	91.8	6.07	6,470	24.6
	04-May-04	1.21	6.30	6.11	6,330	18.9
	18-May-04	1.14	62.6	6.06	5,230	19.6
	02-Jun-04	2.25	77.7	5.97	5,110	19.6
	16-Jun-04	1.66	94.2	5.97	4,650	19.5
	08-Jul-04	2.07	111	6.07	4,140	20.0
	04-Aug-04	0.850	126	5.90	4,090	20.2
	29-Sep-04	1.47	107	5.90	3,710	20.7
	01-Dec-04	2.52	137	5.88	1,710	20.9
	26-Jan-05	ND	94.2	6.04	3,220	20.5
	09-Mar-05		20.2	6.83	3,900	18.4
	24-May-05		13.3	6.16	3,530	19.1
	18-Oct-05		43.7	6.30	4,380	22.1
	02-Nov-05	1.93	69.0	6.16	3,810	21.3
	20-Dec-05	2.30	72.9	5.81	4,490	20.1
	30-Jan-06	2.25	61.5	5.93	4,170	20.1
	15-Mar-06		75.0	5.79	4,620	18.3
	08-May-06	2.82	137	5.67	4,090	19.6
	20-Jun-06		110			
16PM10-D	24-Mar-04	0.710	212	5.03	3,540	18.5
	06-Apr-04	1.42	175	7.02	3,540	23.1
	21-Apr-04	0.510	165	5.12	3,620	23.7
	04-May-04	1.62	165	5.25	3,780	19.0
	19-May-04	1.15	164	5.21	3,520	19.0
	03-Jun-04	1.20	164	5.16	3,430	19.4
	17-Jun-04	2.29	140	5.37	3,570	19.8
	07-Jul-04	2.31	148	5.21	3,480	19.7
	04-Aug-04	1.24	140	5.22	3,560	19.7
	28-Sep-04	2.47	134	5.30	3,610	19.8
	01-Dec-04	2.17	108	5.37	1,760	19.1
	26-Jan-05	0.930	110	5.80	3,330	19.8
	09-Mar-05		113	6.90	3,890	18.3
	24-May-05		48.0	5.99	3,820	19.4
	18-Oct-05		45.4	5.94	5,060	20.2

TABLE F-1: RESULTS OF FIELD PARAMETER ANALYSIS.
Site 16 Landfill, LHAAP, Karnack, Texas

Location	Date Sampled	Dissolved Oxygen (mg/L)	ORP (mV)	pH (std. units)	Specific Conductance (µS/cm)	Temperature (ºC)
16PM10-D Cont.	02-Nov-05	3.52	61.5	6.14	4,580	20.0
	19-Dec-05	0.480	24.1	5.79	2,980	19.2
	30-Jan-06	2.45	-0.900	6.22	5,360	19.4
	14-Mar-06		9.00	6.51	5,230	19.0
	08-May-06	4.02	31.1	6.15	5,130	20.4
	20-Jun-06		21.2			
16PM10-S	24-Mar-04	1.02	227	5.80	7,200	17.2
	06-Apr-04	1.90	136	7.05	7,750	22.0
	21-Apr-04	0.810	43.0	6.18	8,030	23.9
	04-May-04	1.77	-20.5	6.27	7,360	18.5
	19-May-04	0.960	-53.8	6.38	6,350	18.6
	03-Jun-04	1.62	-46.2	6.39	6,590	18.8
	17-Jun-04	2.41	-52.9	6.39	4,050	19.4
	07-Jul-04	2.16	-22.2	6.22	5,860	21.0
	04-Aug-04	4.93	-10.9	6.23	5,090	20.5
	28-Sep-04	3.41	10.4	6.30	3,880	21.1
	01-Dec-04	2.69	39.5	6.19	1,590	19.8
	26-Jan-05	2.33	-16.9	6.85	4,000	19.5
	09-Mar-05		-54.5	6.88	4,270	17.7
	24-May-05		-81.1	6.61	3,100	19.5
	18-Oct-05		-37.1	6.27	3,090	21.9
	02-Nov-05	2.56	-38.6	6.55	3,320	20.8
	19-Dec-05	0.810	-68.1	6.14	2,830	19.2
	30-Jan-06	2.79	-78.1	6.53	3,410	19.1
	14-Mar-06		-61.8	6.75	3,160	18.1
	08-May-06	2.58	-35.2	6.31	1,740	22.7
	20-Jun-06		-21.2			
16PM11	23-Mar-04	1.49	216	6.21	4,610	18.5
	07-Apr-04	2.65	187	6.37	4,960	25.0
	21-Apr-04	1.41	218	6.20	5,520	22.8
	05-May-04	1.81	195	6.31	5,280	17.8
	20-May-04	2.19	221	6.29	4,710	18.2
	03-Jun-04	1.20	228	6.17	4,770	18.7
	17-Jun-04	3.07	123	6.32	4,350	18.7
	08-Jul-04	2.71	229	6.35	3,990	20.4
	04-Aug-04	2.17	336	6.20	4,080	19.9
	28-Sep-04	2.05	174	6.77	3,990	20.1
	01-Dec-04	3.85	112	6.24	1,550	19.1
	26-Jan-05	3.40	148	6.37	2,970	18.3
	10-Mar-05		61.8	6.23	3,500	17.4
	24-May-05		72.7	6.15	3,840	18.8
	18-Oct-05		68.9	6.14	5,140	20.7
	02-Nov-05	6.12	115	6.48	3,210	20.3
	20-Dec-05	1.80	-9.90	5.92	7,250	19.2
	31-Jan-06	5.92	-29.5	6.17	5,960	18.5
	14-Mar-06			6.37	5,550	19.4
	09-May-06	3.72	22.1	6.11	5,050	19.4
	22-Jun-06		50.8			
16PM12	24-Mar-04	1.51	208	5.72	6,580	18.6
	06-Apr-04	1.07	147	5.87	6,510	22.4
	20-Apr-04	0.580	101	5.77	6,940	24.2
	04-May-04	0.690	108	5.81	7,090	19.0

TABLE F-1: RESULTS OF FIELD PARAMETER ANALYSIS.
Site 16 Landfill, LHAAP, Karnack, Texas

Location	Date Sampled	Dissolved Oxygen (mg/L)	ORP (mV)	pH (std. units)	Specific Conductance (µS/cm)	Temperature (ºC)
16PM12 Cont.	19-May-04	0.780	107	5.83	6,390	18.7
	02-Jun-04	2.34	106	5.76	6,320	19.4
	17-Jun-04	2.03	129	5.86	6,380	19.4
	08-Jul-04	2.14	133	5.89	5,710	19.6
	04-Aug-04	1.07	126	5.74	5,960	19.9
	29-Sep-04	1.14	129	5.94	5,240	20.1
	01-Dec-04	2.57	141	5.82	4,770	20.3
	26-Jan-05	2.00	135	5.85	4,230	20.7
	09-Mar-05		31.4	6.78	5,910	19.5
	24-May-05		119	5.92	5,630	19.1
	18-Oct-05		123	5.99	7,730	21.5
	02-Nov-05	1.99	145	6.03	6,490	20.7
	20-Dec-05	28.0	122	5.63	7,760	19.2
	30-Jan-06	2.74	103	5.86	7,910	20.0
	15-Mar-06		115	5.75	7,130	18.5
	08-May-06	2.95	188	5.59	6,750	19.4
	20-Jun-06		163			
16PM13-D	23-Mar-04	1.27		5.60	6,280	18.5
	07-Apr-04	2.23	171	5.79	6,220	22.5
	21-Apr-04	0.660	188	5.65	6,030	23.3
	05-May-04	1.12	190	5.74	5,960	18.3
	19-May-04	0.770	180	5.75	5,200	19.0
	03-Jun-04	1.60	194	5.64	5,140	19.0
	17-Jun-04	1.98	174	5.81	5,010	19.4
	07-Jul-04	2.10	167	5.69	4,830	19.9
	04-Aug-04	2.49	238	5.71	4,780	19.5
	28-Sep-04	2.38	156	5.87	4,610	19.8
	01-Dec-04	2.20	206	5.72	4,420	18.8
	26-Jan-05	1.32	192	5.89	3,890	18.6
	09-Mar-05		167	6.91	5,810	18.3
	14-Mar-05		16.2	6.62	3,690	18.8
	24-May-05		144	5.95	4,730	19.4
	18-Oct-05		118	6.20	6,510	20.1
	02-Nov-05	2.58	150	6.53	5,680	19.0
	19-Dec-05	0.510	-5.70	5.82	3,790	19.0
	30-Jan-06	2.44	-19.1	6.24	5,540	19.2
	08-May-06	4.18	30.5	6.11	5,540	21.1
	22-Jun-06		96.5			
16PM13-S	23-Mar-04	1.19		6.06	3,270	17.3
	07-Apr-04	2.25	125	6.20	3,480	22.0
	21-Apr-04	1.23	152	6.04	3,730	22.4
	05-May-04	1.51	184	6.11	4,300	17.4
	19-May-04	0.990	177	6.03	4,110	18.7
	03-Jun-04	1.90	195	5.94	4,070	18.5
	17-Jun-04	2.28	170	6.06	3,820	19.6
	07-Jul-04	2.21	133	5.87	3,650	19.9
	04-Aug-04	2.10	252	5.94	3,590	20.7
	28-Sep-04	3.12	114	6.08	3,510	21.1
	01-Dec-04	2.31	239	5.95	1,580	19.7
	26-Jan-05	2.25	166	6.25	3,150	18.4
	09-Mar-05		130	6.85	3,690	17.8
	14-Mar-05		46.9	6.38	6,630	18.2

TABLE F-1: RESULTS OF FIELD PARAMETER ANALYSIS.
Site 16 Landfill, LHAAP, Karnack, Texas

Location	Date Sampled	Dissolved Oxygen (mg/L)	ORP (mV)	pH (std. units)	Specific Conductance (µS/cm)	Temperature (ºC)
16PM13-S Cont.	24-May-05		111	6.05	3,290	19.1
	18-Oct-05		102	6.10	4,300	21.4
	02-Nov-05	9.07	151	6.13	4,020	20.6
	19-Dec-05	0.660	98.1	5.60	2,860	19.6
	30-Jan-06	2,010	50.4	6.04	5,950	19.0
	08-May-06	3.51	83.5	5.99	5,590	18.8
	22-Jun-06		91.6			
16PM14	23-Mar-04	1.60	250	6.21	7,090	18.2
	07-Apr-04	2.29	180	6.37	7,210	24.2
	21-Apr-04	1.53	186	6.30	6,630	22.7
	05-May-04	1.31	181	6.33	6,730	17.8
	20-May-04	1.71	176	6.32	6,320	18.5
	03-Jun-04	1.90	217	6.23	6,200	18.7
	17-Jun-04	2.13	148	6.38	5,680	19.4
	08-Jul-04	3.59	204	6.40	5,600	19.6
	04-Aug-04	1.20	295	6.21	5,490	19.6
	28-Sep-04	3.02	194	6.31	4,940	20.1
	01-Dec-04	2.79	149	6.31	4,490	19.4
	26-Jan-05	2.87	152	6.33	4,610	18.3
	10-Mar-05		129	6.30	5,690	17.5
	14-Mar-05			6.43	6,130	19.3
	24-May-05		130	6.24	5,050	19.1
	18-Oct-05		118	6.10	6,600	20.3
	02-Nov-05	3.33	130	6.61	4,390	19.8
	19-Dec-05	2.35	-198	5.85	6.51	19.4
	31-Jan-06	1.29	79.7	6.17	6,290	18.7
	09-May-06	5.51	101	6.14	5,640	19.3
	22-Jun-06		123			
MW10	09-Mar-00	9.13	118	8.36	4,680	10.7
	07-Mar-01	9.94	33.9	8.01	4,040	7.90
	30-Apr-02			8.86	3,790	11.5
	15-Apr-03			7.70		11.5
MW11	13-Dec-00			7.45	1,890	11.8
	15-Apr-03			7.24	2,230	8.20
MW12	08-Mar-00	8.10	121	7.37	1,750	14.6
	10-Mar-00	4.68	67.2	6.92	2,790	11.9
	15-Mar-01		256	6.74	2,610	14.7
	30-Apr-02			7.01	1,520	14.9
	14-Apr-03			7.08	2,760	13.5
MW13	31-May-00	2.75		7.08	1,530	12.0
	13-Dec-00			7.32	1,580	13.7
	15-Apr-03			7.23	1,620	10.0
MW14	31-May-00	2.31	-85.6	6.69	2,870	11.3
	01-Jun-00	4.38	65.9	6.92	3,120	10.6
MW15	08-Mar-00	4.20	145	7.40	1,220	14.5
	10-Mar-00	1.49	-8.80	7.11	1,370	7.30
	13-Dec-00			7.32	1,570	12.9
	15-Mar-01		263	6.90	1,730	8.00
	15-Apr-03			7.20	1,520	9.10
MW16	08-Mar-00	3.60	93.0	7.45	1,510	11.7
	10-Mar-00	5.40	52.6	7.50	1,460	10.5
	13-Dec-00			7.46	1,430	12.8
	15-Mar-01		280	7.55	596	9.00
	15-Apr-03			7.32	1,540	9.70

TABLE F-1: RESULTS OF FIELD PARAMETER ANALYSIS.
Site 16 Landfill, LHAAP, Karnack, Texas

Location	Date Sampled	Dissolved Oxygen (mg/L)	ORP (mV)	pH (std. units)	Specific Conductance (µS/cm)	Temperature (ºC)
MW17	31-May-00	3.03		7.27	5,040	14.6
	08-Mar-01	3.23	215	6.97	5,160	9.80
	30-Apr-02			6.83	3,570	11.8
MW18	08-Mar-00	6.60	70.8	7.72	3,680	13.8
	13-Dec-00			7.11	4,190	14.3
MW2	10-Mar-00	1.99	-24.8	7.40	3,330	7.20
	01-Jun-00	3.32	-120	7.12	3,020	14.3
MW20	10-Mar-00	4.30	105	7.03	11,200	7.50
	07-Mar-01	4.27	154	6.53	12,000	5.40
	11-Jan-02			7.11	5,520	9.90
	15-Apr-03			6.76	14,000	8.40
MW21	09-Mar-00	2.18	-97.5	7.38	2,490	13.1
	07-Mar-01	1.04	-66.3	7.17	2,360	11.3
MW22	08-Mar-00	7.50	-33.4	7.26	1,640	10.9
	10-Mar-00	12.9	-34.0	7.67	1,660	2.60
	13-Dec-00			7.24	1,960	12.8
	14-Apr-03			7.22	1,540	11.2
MW23	10-Mar-00	2.68	-41.2	6.76	2,950	18.2
MW24	10-Mar-00	2.19	-26.9	6.68	3,220	18.4
MW27	08-Mar-00	4.24	54.7	7.29	4,620	12.7
	10-Mar-00	4.47	77.6	7.22	4,950	11.8
	01-Jun-00	1.80	167	7.43	5,680	14.2
	08-Mar-01	2.35	217	6.91	5,340	9.70
	30-Apr-02			6.90	3,650	11.8
MW3	10-Mar-00	6.20	-30.6	7.05	1,740	6.30
	13-Dec-00			7.25	1,650	12.6
	08-Mar-01	1.39	156	7.11	2,230	5.70
MW31	09-Mar-00		179	6.10	1,410	21.7
MW32	09-Mar-00	2.52	197	7.08	1,370	18.7
MW33	08-Mar-00	4.55	-75.0	8.91	857	16.6
MW36	08-Mar-00	2.95	131	9.43	3,170	18.2
	31-May-00	1.15	-221	9.18	2,740	19.7
	29-Jun-00			10.1	2,900	17.8
MW37	09-Mar-00	5.15	-86.8	8.22	11,700	11.6
MW38	26-Jun-01			6.95	4,000 E	19.1
MW39	26-Jun-01			8.18	1,160	20.5
	29-Jun-01			7.00	11,000	19.1
MW4	11-Jan-02			7.13	1,710	8.50
MW40	26-Jun-01			7.47	1,940	19.1
	30-Apr-02			6.93	2,870	17.1
MW41	26-Jun-01			7.30	3,060	19.0
	30-Apr-02			6.94	1,690	17.4
MW42	26-Jun-01			7.34	3,400	18.7
MW43	26-Jun-01			7.22	1,820	18.4
MW44	26-Jun-01			7.13	4,000 E	19.1
	29-Jun-01			7.13	8,770	15.7
MW5	13-Dec-00			7.26	1,710	11.9
MW52	15-Apr-03			7.37	2,190	10.2
MW53	15-Apr-03			7.26	1,420	10.7
MW54	15-Apr-03			7.13	2,480	11.5
MW6	09-Mar-00	8.57	55.4	8.69	12,000	9.70
	07-Mar-01	7.54	40.3	9.72	3,980	6.20

TABLE F-1: RESULTS OF FIELD PARAMETER ANALYSIS.
Site 16 Landfill, LHAAP, Karnack, Texas

Location	Date Sampled	Dissolved Oxygen (mg/L)	ORP (mV)	pH (std. units)	Specific Conductance (µS/cm)	Temperature (ºC)
MW7	10-Mar-00	3.95	86.3	7.39	8,340	7.50
	01-Jun-00	0.730	132	7.13	4,900	12.1
	08-Mar-01	0.710	192	7.00	5,290	6.60
	30-Apr-02			7.02	2,940	9.60
	14-Apr-03			6.97	11,700	7.30
MW8	10-Mar-00	9.46	50.0	7.57	1,100	11.8
	01-Jun-00	3.20	106	6.79	946	13.8
	15-Mar-01		260	6.93	1,040	9.80
	30-Apr-02			7.10	650	10.9
	14-Apr-03			7.45	1,100	11.2
MW9	15-Mar-01		242	7.19	687	11.9
	30-Apr-02			7.43	377	12.9
	14-Apr-03			7.76	547	11.5

TABLE F-2: RESULTS OF PERCHLORATE AND CHLORATE ANALYSIS.
Site 16 Landfill, LHAAP, Karnack, Texas

			Concentration (mg/L)	
Location	Date Sampled	Type	Perchlorate	Chlorate
16EW09	27-Mar-03	Primary	**0.206**	
	24-Mar-04	Primary	**0.749**	30.0 U
	07-Apr-04	Primary	**0.551**	30.0 U
	21-Apr-04	Primary	**0.250**	30.0 U
	21-Apr-04	Dup	**0.306**	30.0 U
	05-May-04	Primary	**0.224**	30.0 U
	20-May-04	Primary	**0.373**	30.0 U
	04-Jun-04	Primary	**0.188**	30.0 U
	17-Jun-04	Primary	**0.133**	0.100 U
	17-Jun-04	Dup	**0.184**	0.100 U
	04-Aug-04	Primary	**0.160**	0.100 U
	04-Aug-04	Dup	**0.125**	0.100 U
	29-Sep-04	Primary	**0.0815**	0.100 U
	02-Dec-04	Primary	**0.0663**	0.100 U
	26-Jan-05	Primary	**0.192**	0.100 U
	10-Mar-05	Primary	**0.128**	0.100 U
	25-May-05	Primary	**0.352**	0.100 U
	19-Oct-05	Primary	0.00400 U	
	02-Nov-05	Primary	0.00400 U	
	02-Nov-05	Dup	0.00400 U	
	19-Dec-05	Primary	0.00400 U	
	30-Jan-06	Primary	**0.0940**	
	15-Mar-06	Primary	0.00400 U	
16EW10	27-Mar-03	Primary	**0.257**	
	23-Mar-04	Primary	**0.111**	30.0 U
	07-Apr-04	Primary	**0.129**	30.0 U
	21-Apr-04	Primary	**0.149**	30.0 U
	21-Apr-04	Dup	**0.106**	30.0 U
	05-May-04	Primary	**0.0760**	30.0 U
	20-May-04	Primary	**0.187**	30.0 U
	20-May-04	Dup	**0.198**	30.0 U
	04-Jun-04	Primary	**0.0744**	30.0 U
	18-Jun-04	Primary	**0.0430**	0.100 U
	07-Jul-04	Primary	**0.141**	0.100 U
	04-Aug-04	Primary	**0.130**	0.100 U
	29-Sep-04	Primary	**0.110**	0.100 U
	02-Dec-04	Primary	**0.0311**	0.100 U
	26-Jan-05	Primary	**0.00530**	0.100 U
	10-Mar-05	Primary	**0.0546**	0.100 U
	25-May-05	Primary	0.00400 U	0.100 U
	19-Oct-05	Primary	**0.0900**	
	19-Oct-05	Dup	**0.0920**	
	02-Nov-05	Primary	0.00400 U	
	19-Dec-05	Primary	0.00400 U	
	30-Jan-06	Primary	0.00400 U	
	15-Mar-06	Primary	0.00400 U	
	15-Mar-06	Dup	0.00400 U	

TABLE F-2: RESULTS OF PERCHLORATE AND CHLORATE ANALYSIS.
Site 16 Landfill, LHAAP, Karnack, Texas

			Concentration (mg/L)	
Location	Date Sampled	Type	Perchlorate	Chlorate
16EW11	27-Mar-03	Primary	**0.326**	
	25-May-05	Primary	0.00400 U	0.100 U
16EW12	30-Jun-03	Primary	**0.0786**	
	25-May-05	Primary	0.00400 U	0.100 U
	19-Oct-05	Primary	0.00400 U	
	02-Nov-05	Primary	**1.84**	
	19-Dec-05	Primary	0.00400 U	
	30-Jan-06	Primary	**0.0218**	
	16-Mar-06	Primary	0.00400 U	
16EW12B	24-Mar-04	Primary	**1.04**	30.0 U
	07-Apr-04	Primary	**1.11**	30.0 U
	21-Apr-04	Primary	**0.424**	30.0 U
	05-May-04	Primary	**0.103**	30.0 U
	20-May-04	Primary	**0.0630**	30.0 U
	04-Jun-04	Primary	**0.0609**	30.0 U
	18-Jun-04	Primary	**0.0118**	0.100 U
	07-Jul-04	Primary	**0.0212**	0.100 U
	04-Aug-04	Primary	**0.0330**	0.100 U
	29-Sep-04	Primary	**0.0650**	0.100 U
	02-Dec-04	Primary	**0.0183**	0.100 U
	26-Jan-05	Primary	0.00400 U	0.100 U
	10-Mar-05	Primary	**0.0223**	0.100 U
	25-May-05	Primary	0.00400 U	0.100 U
	19-Oct-05	Primary	**0.0470**	
	02-Nov-05	Primary	**1.13**	
	19-Dec-05	Primary	0.00400 U	
	30-Jan-06	Primary	**0.0175**	
	16-Mar-06	Primary	0.00400 U	
16EW13	26-Jun-03	Primary	**0.0386**	
	25-May-05	Primary	0.00400 U	0.100 U
16EW14	26-Jun-03	Primary	**0.0397**	
	25-May-05	Primary	0.00400 U	0.100 U
	25-May-05	Dup	0.00400 U	0.100 U
16EW14B	24-Mar-04	Primary	**1.00**	30.0 U
	07-Apr-04	Primary	**1.09**	30.0 U
	21-Apr-04	Primary	**0.0370**	30.0 U
	05-May-04	Primary	0.00400 U	30.0 U
	20-May-04	Primary	**0.142**	30.0 U
	04-Jun-04	Primary	**0.0298**	30.0 U
	17-Jun-04	Primary	**0.0388**	0.100 U
	17-Jun-04	Dup	**0.0839**	0.100 U
	07-Jul-04	Primary	**0.00550**	0.100 U
	04-Aug-04	Primary	**0.0144**	0.100 U
	29-Sep-04	Primary	**0.0707**	0.100 U
	02-Dec-04	Primary	**0.0376**	0.100 U
	26-Jan-05	Primary	0.00400 U	0.100 U
	10-Mar-05	Primary	0.00400 U	0.100 U
	25-May-05	Primary	0.00400 U	0.100 U

TABLE F-2: RESULTS OF PERCHLORATE AND CHLORATE ANALYSIS.
Site 16 Landfill, LHAAP, Karnack, Texas

			Concentration (mg/L)	
Location	Date Sampled	Type	Perchlorate	Chlorate
16EW15	26-Jun-03	Primary	**0.768**	
	26-Jun-03	Dup	**0.731**	
	25-May-05	Primary	**0.0385**	0.100 U
16PM01	26-Jun-03	Primary	0.00400 U	
	23-Mar-04	Primary	0.00400 U	30.0 U
	06-Apr-04	Primary	0.00400 U	30.0 U
	20-Apr-04	Primary	**0.0880**	30.0 U
	04-May-04	Primary	0.00400 U	30.0 U
	18-May-04	Primary	**0.00500**	30.0 U
	02-Jun-04	Primary	0.00400 U	30.0 U
	16-Jun-04	Primary	0.00400 U	0.100 U
	04-Aug-04	Primary	0.00400 U	0.100 U
	04-Aug-04	Dup	0.00400 U	0.100 U
	30-Sep-04	Primary	0.00400 U	0.100 U
	01-Dec-04	Primary	0.00400 U	0.100 U
	26-Jan-05	Primary	0.00400 U	0.100 U
	26-Jan-05	Dup	0.00400 U	0.100 U
	10-Mar-05	Primary	0.00400 U	0.100 U
	24-May-05	Primary	0.00400 U	0.100 U
	19-Oct-05	Primary	**0.109**	
	02-Nov-05	Primary	0.00400 U	
	19-Dec-05	Primary	0.00400 U	
	31-Jan-06	Primary	0.00400 U	
	14-Mar-06	Primary	0.00400 U	
16PM02	26-Jun-03	Primary	**0.0272**	
	23-Mar-04	Primary	0.00400 U	30.0 U
	06-Apr-04	Primary	0.00400 U	30.0 U
	20-Apr-04	Primary	**0.00900**	30.0 U
	04-May-04	Primary	**0.00500**	30.0 U
	18-May-04	Primary	**0.00900**	30.0 U
	02-Jun-04	Primary	0.00400 U	30.0 U
	16-Jun-04	Primary	0.00400 U	0.100 U
	04-Aug-04	Primary	**0.00830**	0.100 U
	30-Sep-04	Primary	**0.0334**	0.100 U
	01-Dec-04	Primary	**0.0105**	0.100 U
	26-Jan-05	Primary	**0.0421**	0.100 U
	26-Jan-05	Dup	**0.0460**	0.100 U
	10-Mar-05	Primary	**0.153**	0.100 U
	24-May-05	Primary	0.00400 U	0.100 U
	19-Oct-05	Primary	**0.00800**	
	02-Nov-05	Primary	0.00400 U	
	19-Dec-05	Primary	0.00400 U	
	31-Jan-06	Primary	**4.09**	
	14-Mar-06	Primary	**0.0190**	
16PM03	30-Jun-03	Primary	**1.65**	
	23-Mar-04	Primary	**1.69**	30.0 U
	06-Apr-04	Primary	**1.96**	30.0 U
	20-Apr-04	Primary	**1.99**	30.0 U
	04-May-04	Primary	**1.75**	30.0 U

TABLE F-2: RESULTS OF PERCHLORATE AND CHLORATE ANALYSIS.
Site 16 Landfill, LHAAP, Karnack, Texas

			Concentration (mg/L)	
Location	Date Sampled	Type	Perchlorate	Chlorate
16PM03	18-May-04	Primary	**1.60**	30.0 U
Cont.	02-Jun-04	Primary	**1.46**	30.0 U
	16-Jun-04	Primary	**1.42**	0.100 U
	04-Aug-04	Primary	**0.883**	0.100 U
	30-Sep-04	Primary	**1.46**	0.100 U
	01-Dec-04	Primary	**1.62**	0.100 U
	26-Jan-05	Primary	**1.35**	0.100 U
	10-Mar-05	Primary	**1.18**	0.100 U
	24-May-05	Primary	**1.51**	0.100 U
	24-May-05	Dup	**1.56**	0.100 U
	19-Oct-05	Primary	**14.0**	
	02-Nov-05	Primary	**0.280**	
	19-Dec-05	Primary	**2.70**	
	31-Jan-06	Primary	**4.05**	
	31-Jan-06	Dup	**4.27**	
	14-Mar-06	Primary	**4.55**	
16PM04	27-Jun-03	Primary	0.00400 U	
	23-Mar-04	Primary	**0.286**	30.0 U
	06-Apr-04	Primary	**0.589**	30.0 U
	20-Apr-04	Primary	**0.340**	30.0 U
	04-May-04	Primary	**0.213**	30.0 U
	04-May-04	Dup	**0.190**	30.0 U
	18-May-04	Primary	**0.190**	30.0 U
	18-May-04	Dup	**0.138**	30.0 U
	03-Jun-04	Primary	**0.106**	30.0 U
	16-Jun-04	Primary	**0.0147**	0.100 U
	07-Jul-04	Primary	**0.0625**	0.100 U
	04-Aug-04	Primary	**0.0642**	0.100 U
	30-Sep-04	Primary	**0.0680**	0.100 U
	01-Dec-04	Primary	**0.0299**	0.100 U
	26-Jan-05	Primary	**0.00400**	0.100 U
	10-Mar-05	Primary	**0.0141**	0.100 U
	10-Mar-05	Dup	**0.0138**	0.100 U
	24-May-05	Primary	**0.0439**	0.100 U
	19-Oct-05	Primary	0.00400 U	
	02-Nov-05	Primary	**0.0870**	
	19-Dec-05	Primary	0.00400 U	
	30-Jan-06	Primary	0.00400 U	
	15-Mar-06	Primary	0.00400 U	
16PM05	26-Jun-03	Primary	**1.33**	
	24-Mar-04	Primary	**0.883**	30.0 U
	24-Mar-04	Dup	**1.06**	
	06-Apr-04	Primary	**0.738**	30.0 U
	20-Apr-04	Primary	**0.145**	30.0 U
	04-May-04	Primary	**0.117**	30.0 U
	18-May-04	Primary	**0.134**	30.0 U
	02-Jun-04	Primary	**0.0794**	30.0 U
	16-Jun-04	Primary	**0.165**	0.100 U
	07-Jul-04	Primary	**0.0159**	0.100 U

TABLE F-2: RESULTS OF PERCHLORATE AND CHLORATE ANALYSIS.
Site 16 Landfill, LHAAP, Karnack, Texas

			Concentration (mg/L)	
Location	Date Sampled	Type	Perchlorate	Chlorate
16PM05	04-Aug-04	Primary	**0.0111**	0.100 U
Cont.	29-Sep-04	Primary	**0.0164**	0.100 U
	29-Sep-04	Dup	**0.0214**	0.100 U
	01-Dec-04	Primary	**0.0117**	0.100 U
	01-Dec-04	Dup	**0.0211**	0.100 U
	26-Jan-05	Primary	0.00400 U	0.100 U
	10-Mar-05	Primary	**0.0137**	0.100 U
	24-May-05	Primary	**0.0920**	0.100 U
	19-Oct-05	Primary	**0.0400**	
	19-Oct-05	Dup	**0.0380**	
	02-Nov-05	Primary	**0.889**	
	19-Dec-05	Primary	0.00400 U	
	30-Jan-06	Primary	0.00400 U	
	15-Mar-06	Primary	0.00400 U	
16PM06	27-Jun-03	Primary	**0.0299**	
	23-Mar-04	Primary	**0.968**	30.0 U
	06-Apr-04	Primary	**0.703**	30.0 U
	20-Apr-04	Primary	**0.128**	30.0 U
	04-May-04	Primary	**0.0400**	30.0 U
	19-May-04	Primary	**0.374**	30.0 U
	02-Jun-04	Primary	**0.0917**	30.0 U
	16-Jun-04	Primary	**0.0218**	0.100 U
	07-Jul-04	Primary	**0.00400**	0.100 U
	04-Aug-04	Primary	**0.00600**	0.100 U
	30-Sep-04	Primary	**0.0429**	0.100 U
	30-Sep-04	Dup	**0.0384**	0.100 U
	01-Dec-04	Primary	**0.00680**	0.100 U
	01-Dec-04	Dup	**0.00630**	0.100 U
	26-Jan-05	Primary	0.00400 U	0.100 U
	10-Mar-05	Primary	0.00400 U	0.100 U
	24-May-05	Primary	0.00400 U	0.100 U
	19-Oct-05	Primary	**0.0110**	
	02-Nov-05	Primary	**0.0820**	
	19-Dec-05	Primary	0.00400 U	
	30-Jan-06	Primary	**0.0980**	
	14-Mar-06	Primary	**0.00700**	
16PM07-D	27-Jun-03	Primary	**0.0356**	
	23-Mar-04	Primary	0.00400 U	30.0 U
	07-Apr-04	Primary	0.00400 U	30.0 U
	20-Apr-04	Primary	**0.0160**	30.0 U
	04-May-04	Primary	**0.00800**	30.0 U
	19-May-04	Primary	**0.0630**	30.0 U
	03-Jun-04	Primary	**0.0303**	30.0 U
	16-Jun-04	Primary	**0.0532**	0.100 U
	07-Jul-04	Primary	**0.0727**	0.100 U
	04-Aug-04	Primary	**0.208**	0.100 U
	30-Sep-04	Primary	**0.0959**	0.100 U
	01-Dec-04	Primary	**0.00820**	0.100 U

TABLE F-2: RESULTS OF PERCHLORATE AND CHLORATE ANALYSIS.
Site 16 Landfill, LHAAP, Karnack, Texas

			Concentration (mg/L)	
Location	Date Sampled	Type	Perchlorate	Chlorate
16PM07-D Cont.	26-Jan-05	Primary	0.00400 U	0.100 U
	10-Mar-05	Primary	0.00400 U	0.100 U
	24-May-05	Primary	0.00400 U	0.100 U
	19-Oct-05	Primary	**0.0610**	
	02-Nov-05	Primary	**0.386**	
	19-Dec-05	Primary	0.00400 U	
	30-Jan-06	Primary	**0.0560**	
	14-Mar-06	Primary	**0.0265**	
16PM07-S	27-Jun-03	Primary	**0.0437**	
	23-Mar-04	Primary	**0.0385**	30.0 U
	06-Apr-04	Primary	**0.0890**	30.0 U
	20-Apr-04	Primary	**0.106**	30.0 U
	04-May-04	Primary	**0.0950**	30.0 U
	19-May-04	Primary	**0.177**	30.0 U
	03-Jun-04	Primary	**0.0602**	30.0 U
	16-Jun-04	Primary	**0.0576**	0.100 U
	07-Jul-04	Primary	**0.0313**	0.100 U
	04-Aug-04	Primary	**0.0861**	0.100 U
	30-Sep-04	Primary	**0.0756**	0.100 U
	01-Dec-04	Primary	**0.00550**	0.100 U
	26-Jan-05	Primary	0.00400 U	0.100 U
	10-Mar-05	Primary	0.00400 U	0.100 U
	24-May-05	Primary	0.00400 U	0.100 U
	19-Oct-05	Primary	**0.0190**	
	02-Nov-05	Primary	**0.0850**	
	19-Dec-05	Primary	0.00400 U	
	30-Jan-06	Primary	**0.0730**	
	14-Mar-06	Primary	**0.0100**	
16PM08	27-Jun-03	Primary	**0.0532**	
	27-Jun-03	Dup	**0.0555**	
	23-Mar-04	Primary	**0.129**	30.0 U
	07-Apr-04	Primary	**0.176**	30.0 U
	07-Apr-04	Dup	**0.172**	30.0 U
	21-Apr-04	Primary	**0.157**	30.0 U
	05-May-04	Primary	**0.111**	30.0 U
	19-May-04	Primary	**0.126**	30.0 U
	03-Jun-04	Primary	**0.0894**	30.0 U
	16-Jun-04	Primary	**0.0643**	0.100 U
	07-Jul-04	Primary	**0.0558**	0.100 U
	07-Jul-04	Dup	**0.0646**	0.100 U
	04-Aug-04	Primary	**0.0350**	0.100 U
	30-Sep-04	Primary	**0.0640**	0.100 U
	01-Dec-04	Primary	**0.0302**	0.100 U
	26-Jan-05	Primary	**0.0732**	0.100 U
	10-Mar-05	Primary	**0.0336**	0.100 U
	10-Mar-05	Dup	**0.0299**	0.100 U
	24-May-05	Primary	**0.0245**	0.100 U
	19-Oct-05	Primary	**0.00600**	
	02-Nov-05	Primary	**5.60**	

TABLE F-2: RESULTS OF PERCHLORATE AND CHLORATE ANALYSIS.
Site 16 Landfill, LHAAP, Karnack, Texas

			Concentration (mg/L)	
Location	Date Sampled	Type	Perchlorate	Chlorate
16PM08	02-Nov-05	Dup	**5.54**	
Cont.	19-Dec-05	Primary	0.00400 U	
	31-Jan-06	Primary	**0.00400**	
	14-Mar-06	Primary	0.00400 U	
	14-Mar-06	Dup	0.00400 U	
16PM09	26-Jun-03	Primary	**0.183**	
	24-Mar-04	Primary	**0.918**	30.0 U
	06-Apr-04	Primary	**0.905**	30.0 U
	20-Apr-04	Primary	**0.391**	30.0 U
	04-May-04	Primary	**0.239**	30.0 U
	18-May-04	Primary	**0.146**	30.0 U
	02-Jun-04	Primary	**0.148**	30.0 U
	02-Jun-04	Dup	**0.148**	30.0 U
	16-Jun-04	Primary	**0.0538**	0.100 U
	07-Jul-04	Primary	**0.0117**	0.100 U
	04-Aug-04	Primary	**0.0589**	0.100 U
	29-Sep-04	Primary	**0.0290**	0.100 U
	01-Dec-04	Primary	**0.0216**	0.100 U
	26-Jan-05	Primary	**0.0380**	0.100 U
	10-Mar-05	Primary	**0.00600**	0.100 U
	24-May-05	Primary	**0.0135**	0.100 U
	19-Oct-05	Primary	**0.0306**	
	02-Nov-05	Primary	**0.375**	
	19-Dec-05	Primary	0.00400 U	
	30-Jan-06	Primary	0.00400 U	
	15-Mar-06	Primary	0.00400 U	
16PM10-D	27-Jun-03	Primary	**0.155**	
	24-Mar-04	Primary	**0.0685**	30.0 U
	06-Apr-04	Primary	**0.121**	30.0 U
	21-Apr-04	Primary	**0.132**	30.0 U
	04-May-04	Primary	**0.130**	30.0 U
	19-May-04	Primary	**0.156**	30.0 U
	03-Jun-04	Primary	**0.0902**	30.0 U
	17-Jun-04	Primary	**0.0780**	0.100 U
	07-Jul-04	Primary	**0.0787**	0.100 U
	04-Aug-04	Primary	**0.0837**	0.100 U
	30-Sep-04	Primary	**0.194**	0.100 U
	01-Dec-04	Primary	**0.0369**	0.100 U
	26-Jan-05	Primary	0.00400 U	0.100 U
	10-Mar-05	Primary	0.00400 U	0.100 U
	24-May-05	Primary	0.00400 U	0.100 U
	19-Oct-05	Primary	**0.0590**	
	02-Nov-05	Primary	0.00400 U	
	19-Dec-05	Primary	0.00400 U	
	30-Jan-06	Primary	**0.119**	
	30-Jan-06	Dup	**0.111**	
	14-Mar-06	Primary	0.00400 U	

TABLE F-2: RESULTS OF PERCHLORATE AND CHLORATE ANALYSIS.
Site 16 Landfill, LHAAP, Karnack, Texas

			Concentration (mg/L)	
Location	Date Sampled	Type	Perchlorate	Chlorate
16PM10-S	27-Jun-03	Primary	**0.0425**	
	24-Mar-04	Primary	**0.669**	30.0 U
	06-Apr-04	Primary	**0.805**	30.0 U
	21-Apr-04	Primary	**0.104**	30.0 U
	04-May-04	Primary	**0.0510**	30.0 U
	19-May-04	Primary	**0.340**	30.0 U
	03-Jun-04	Primary	**0.0622**	30.0 U
	17-Jun-04	Primary	**0.0215**	0.100 U
	07-Jul-04	Primary	0.00400 U	0.100 U
	04-Aug-04	Primary	**0.0259**	0.100 U
	30-Sep-04	Primary	0.00400 U	0.100 U
	01-Dec-04	Primary	**0.00870**	0.100 U
	26-Jan-05	Primary	0.00400 U	0.100 U
	10-Mar-05	Primary	0.00400 U	0.100 U
	24-May-05	Primary	0.00400 U	0.100 U
	19-Oct-05	Primary	**0.0141**	
	02-Nov-05	Primary	**0.230**	
	19-Dec-05	Primary	0.00400 U	
	30-Jan-06	Primary	**0.106**	
	14-Mar-06	Primary	**0.00750**	
16PM11	27-Jun-03	Primary	**0.178**	
	23-Mar-04	Primary	**0.161**	30.0 U
	07-Apr-04	Primary	**0.197**	30.0 U
	07-Apr-04	Dup	**0.192**	30.0 U
	21-Apr-04	Primary	**0.282**	30.0 U
	04-May-04	Primary	**0.191**	30.0 U
	20-May-04	Primary	**0.258**	30.0 U
	03-Jun-04	Primary	**0.146**	30.0 U
	03-Jun-04	Dup	**0.134**	30.0 U
	17-Jun-04	Primary	**0.0949**	0.100 U
	07-Jul-04	Primary	**0.104**	0.100 U
	07-Jul-04	Dup	**0.0999**	0.100 U
	04-Aug-04	Primary	**0.0684**	0.100 U
	30-Sep-04	Primary	**0.135**	0.100 U
	01-Dec-04	Primary	**0.0413**	0.100 U
	26-Jan-05	Primary	**0.0391**	0.100 U
	10-Mar-05	Primary	**0.0219**	0.100 U
	24-May-05	Primary	**0.0171**	0.100 U
	19-Oct-05	Primary	**0.0610**	
	02-Nov-05	Primary	**0.371**	
	19-Dec-05	Primary	0.00400 U	
	19-Dec-05	Dup	0.00400 U	
	31-Jan-06	Primary	**0.0140**	
	14-Mar-06	Primary	0.00400 U	
16PM12	26-Jun-03	Primary	**0.523**	
	24-Mar-04	Primary	**0.132**	30.0 U
	06-Apr-04	Primary	**0.144**	30.0 U
	20-Apr-04	Primary	**0.391**	30.0 U
	04-May-04	Primary	**0.260**	30.0 U

TABLE F-2: RESULTS OF PERCHLORATE AND CHLORATE ANALYSIS.
Site 16 Landfill, LHAAP, Karnack, Texas

			Concentration (mg/L)	
Location	Date Sampled	Type	Perchlorate	Chlorate
16PM12	04-May-04	Dup	**0.250**	30.0 U
Cont.	19-May-04	Primary	**0.0720**	30.0 U
	02-Jun-04	Primary	**0.0779**	30.0 U
	17-Jun-04	Primary	**0.0167**	0.100 U
	07-Jul-04	Primary	**0.0113**	0.100 U
	04-Aug-04	Primary	**0.116**	0.100 U
	29-Sep-04	Primary	**0.0201**	0.100 U
	01-Dec-04	Primary	**0.0958**	0.100 U
	26-Jan-05	Primary	**0.268**	0.100 U
	10-Mar-05	Primary	**0.373**	0.100 U
	24-May-05	Primary	**0.525**	0.100 U
	19-Oct-05	Primary	0.00400 U	
	02-Nov-05	Primary	**0.831**	
	19-Dec-05	Primary	0.00400 U	
	30-Jan-06	Primary	**0.180**	
	15-Mar-06	Primary	**7.68**	
16PM13-D	27-Jun-03	Primary	**0.470**	
	23-Mar-04	Primary	**0.220**	30.0 U
	07-Apr-04	Primary	**0.373**	30.0 U
	21-Apr-04	Primary	**0.267**	30.0 U
	05-May-04	Primary	**0.177**	30.0 U
	19-May-04	Primary	**0.279**	30.0 U
	03-Jun-04	Primary	**0.0874**	30.0 U
	17-Jun-04	Primary	**0.0109**	0.100 U
	07-Jul-04	Primary	**0.0933**	0.100 U
	04-Aug-04	Primary	**0.160**	0.100 U
	30-Sep-04	Primary	**0.252**	0.100 U
	01-Dec-04	Primary	**0.395**	0.100 U
	26-Jan-05	Primary	**0.279**	0.100 U
	10-Mar-05	Primary	**0.0709**	0.100 U
	24-May-05	Primary	0.00400 U	0.100 U
	19-Oct-05	Primary	**0.0900**	
	02-Nov-05	Primary	0.00400 U	
	19-Dec-05	Primary	0.00400 U	
	30-Jan-06	Primary	**0.136**	
	14-Mar-06	Primary	0.00400 U	
16PM13-S	27-Jun-03	Primary	**0.180**	
	23-Mar-04	Primary	0.00400 U	30.0 U
	07-Apr-04	Primary	**0.304**	30.0 U
	21-Apr-04	Primary	**0.0410**	30.0 U
	05-May-04	Primary	**0.110**	30.0 U
	19-May-04	Primary	**0.165**	30.0 U
	03-Jun-04	Primary	**0.0844**	30.0 U
	17-Jun-04	Primary	**0.0491**	0.100 U
	07-Jul-04	Primary	**0.0546**	0.100 U
	04-Aug-04	Primary	**0.0650**	0.100 U
	30-Sep-04	Primary	**0.0522**	0.100 U
	01-Dec-04	Primary	**0.0178**	0.100 U
	26-Jan-05	Primary	**0.00990**	0.100 U

TABLE F-2: RESULTS OF PERCHLORATE AND CHLORATE ANALYSIS.
Site 16 Landfill, LHAAP, Karnack, Texas

			Concentration (mg/L)	
Location	Date Sampled	Type	Perchlorate	Chlorate
16PM13-S	10-Mar-05	Primary	**0.00560**	0.100 U
Cont.	24-May-05	Primary	**0.0650**	0.100 U
	19-Oct-05	Primary	**0.280**	
	02-Nov-05	Primary	**0.511**	
	19-Dec-05	Primary	**0.0280**	
	30-Jan-06	Primary	**0.165**	
	14-Mar-06	Primary	0.00400 U	
16PM14	27-Jun-03	Primary	**0.305**	
	23-Mar-04	Primary	**0.428**	30.0 U
	23-Mar-04	Dup	**0.425**	30.0 U
	07-Apr-04	Primary	**0.709**	30.0 U
	21-Apr-04	Primary	**0.518**	30.0 U
	05-May-04	Primary	**0.421**	30.0 U
	19-May-04	Primary	**0.488**	30.0 U
	03-Jun-04	Primary	**0.380**	30.0 U
	17-Jun-04	Primary	**0.318**	0.100 U
	07-Jul-04	Primary	**0.270**	0.100 U
	04-Aug-04	Primary	**0.197**	0.100 U
	30-Sep-04	Primary	**0.281**	0.100 U
	01-Dec-04	Primary	**0.389**	0.100 U
	26-Jan-05	Primary	**0.379**	0.100 U
	10-Mar-05	Primary	**0.179**	0.100 U
	24-May-05	Primary	**0.102**	0.100 U
	19-Oct-05	Primary	**0.135**	
	02-Nov-05	Primary	**0.228**	
	19-Dec-05	Primary	0.00400 U	
	19-Dec-05	Dup	0.00400 U	
	31-Jan-06	Primary	**0.165**	
	14-Mar-06	Primary	**0.00400**	
16WW16	30-Jun-03	Primary	**0.243**	

TABLE F-3: RESULTS OF ANIONS ANALYSIS.
Site 16 Landfill, LHAAP, Karnack, Texas

			Concentration (mg/L)									
Location	Date Sampled	Type	Chloride	Fluoride	Nitrate	Nitrate Nitrogen	Nitrate-Nitrite	Nitrite Nitrogen	Phosphate	Phosphorus	Sulfate	Sulfide
16EW09	27-Mar-03	Primary	**667**			0.200 U		**9.29**			**3,700**	2.00 U
	24-Mar-04	Primary	**2,840**			2.00 U		2.00 U		0.0500 U	**4,790**	1.00 U
	07-Apr-04	Primary	**519**		0.0200 U			0.0160 U	0.0300 U		**2,060**	
	21-Apr-04	Primary	**1,310**		**32.0**			0.0160 U	0.0300 U		**6,900**	
	21-Apr-04	Dup	**1,300**		0.0200 U			**19.0**	0.0300 U		**6,800**	
	21-Apr-04	Primary				2.00 U	2.00 U	2.00 U				1.00 U
	21-Apr-04	Dup				2.00 U	**2.00**	**2.00**				1.00 U
	05-May-04	Primary	**1,230**		0.0200 U			0.0160 U	0.0300 U		**6,040**	
	20-May-04	Primary	**780**		0.0200 U			0.0160 U			**3,320**	
	20-May-04	Primary				2.00 U	2.00 U	2.00 U				0.100 U
	04-Jun-04	Primary	**859**		0.400 U			0.200 U			**3,630**	
	17-Jun-04	Primary			0.0330 U			0.0330 U		0.0750 U	**461**	
	17-Jun-04	Dup			0.0330 U			0.0330 U		0.0750 U	**2,690**	
	04-Aug-04	Primary	**909**	**0.0690**	0.400 U			0.200 U		0.600 U	**4,440**	**0.0650**
	04-Aug-04	Dup	**903**	**0.0570**	0.400 U			0.200 U		0.600 U	**4,490**	**0.0800**
	29-Sep-04	Primary	**1,300**	**0.140**	0.400 U			0.200 U	0.600 U		**5,600**	**0.153**
	02-Dec-04	Primary	**0.834**									
	26-Jan-05	Primary	**825**	**0.0500**	0.400 U			0.200 U		0.600 U	**4,360**	**0.0170**
	10-Mar-05	Primary	**849**									
	25-May-05	Primary	**780**	0.0800 U	0.400 U			0.200 U		0.600 U	**3,600**	**0.0120**
16EW10	27-Mar-03	Primary	**498**			**0.870**		**8.23**			**497**	1.00 U
	23-Mar-04	Primary	**1,580**			2.00 U		2.00 U		**1.51**	**2,190**	1.00 U
	07-Apr-04	Primary	**400**		**0.790**			**0.0800**	0.0300 U		**1,450**	
	21-Apr-04	Primary	**894**		**728**			**125**	0.0300 U		**2,770**	
	21-Apr-04	Dup	**884**		0.0200 U			**30.0**	0.0300 U		**2,730**	
	21-Apr-04	Primary				2.00 U	**8.80**	**7.30**				1.00 U
	21-Apr-04	Dup				2.00 U	**9.20**	**7.60**				1.00 U
	05-May-04	Primary	**904**		**0.939**			**0.185**	0.0300 U		**2,940**	
	20-May-04	Primary	**537**		**1.40**			0.0160 U			**1,700**	
	20-May-04	Dup	**551**		**1.30**			0.0160 U			**1,750**	
	20-May-04	Primary				2.00 U	2.00 U	2.00 U				0.100 U
	20-May-04	Dup				2.00 U	2.00 U	2.00 U				0.100 U
	04-Jun-04	Primary	**608**		**0.870**			0.200 U			**1,920**	
	18-Jun-04	Primary			**0.656**			0.0330 U		0.0750 U	**2,190**	
	07-Jul-04	Primary	**708**	**0.0800**	**0.350**			**0.230**		0.600 U	**2,950**	
	04-Aug-04	Primary	**603**	**0.0590**	0.400 U			0.200 U		0.600 U	**2,800**	**0.0560**
	29-Sep-04	Primary	**645**	0.0800 U	0.400 U			0.200 U	0.600 U		**2,120**	**0.123**
	02-Dec-04	Primary	**0.585**									
	26-Jan-05	Primary	**618**	**0.0200**	0.400 U			0.200 U		0.600 U	**3,020**	**0.0270**
	10-Mar-05	Primary	**645**									
	25-May-05	Primary	**618**	**0.360**	0.400 U			0.200 U		0.600 U	**2,560**	**0.0170**
16EW11	27-Mar-03	Primary	**791**			**2.22**		**1.82**			**906**	1.00 U
	25-May-05	Primary	**570**	0.0800 U	0.400 U			0.200 U		0.600 U	**1,690**	**8.80 E**
16EW12	30-Jun-03	Primary	**460**			0.200 U		**0.870**			**457**	1.00 U
	25-May-05	Primary	**450**	0.0800 U	0.400 U			0.200 U		0.600 U	**19.0**	**0.0250**
16EW12B	24-Mar-04	Primary	**1,120**			**4.20**		2.00 U		0.0500 U	**2,730**	1.00 U
	07-Apr-04	Primary	**470**		**8.62**			**0.440**	0.0300 U		**2,260**	
	21-Apr-04	Primary	**865**		0.0200 U			**1,560**	0.0300 U		**1,630**	
	21-Apr-04	Primary				2.00 U	**25.7**	**24.0**				1.00 U
	05-May-04	Primary	**894**		0.0200 U			0.0160 U	0.0300 U		**1,780**	
	20-May-04	Primary	**694**		0.0200 U			0.0160 U			**1,360**	
	20-May-04	Primary				2.00 U	**3.30**	**3.30**				0.100 U
	04-Jun-04	Primary	**688**		**0.710**			0.200 U			**1,120**	
	18-Jun-04	Primary			**0.297**			0.0330 U		0.0750 U	**179**	
	07-Jul-04	Primary	**774**	**0.0500**	0.400 U			0.200 U		0.600 U	**1,090**	
	04-Aug-04	Primary	**657**	**0.0760**	**0.100**			0.200 U		0.600 U	**936**	**0.0270**
16EW12B Cont.	29-Sep-04	Primary	**621**	**1.02**	0.400 U			0.200 U	0.600 U		**1,310**	**0.0100**
	02-Dec-04	Primary	**0.720**									
	26-Jan-05	Primary	**612**	0.0800 U	0.400 U			0.200 U		0.600 U	**939**	**0.508**
	10-Mar-05	Primary	**744**									
	25-May-05	Primary	**735**	0.0800 U	0.400 U			0.200 U		0.600 U	**1,240**	**0.0210**

TABLE F-3: RESULTS OF ANIONS ANALYSIS.
Site 16 Landfill, LHAAP, Karnack, Texas

			Concentration (mg/L)									
Location	Date Sampled	Type	Chloride	Fluoride	Nitrate	Nitrate Nitrogen	Nitrate-Nitrite	Nitrite Nitrogen	Phosphate	Phosphorus	Sulfate	Sulfide
16EW13	26-Jun-03	Primary	**339**			0.200 U		**0.810**			**527**	2.50 U
	25-May-05	Primary	**540**	**0.110**	0.400 U			0.200 U		0.600 U	**1,700**	**8.80 E**
16EW14	26-Jun-03	Primary	**260**			0.200 U		**3.02**			**243**	1.00 U
	25-May-05	Primary	**102**	**13.8**	0.400 U			0.200 U		0.600 U	**39.0**	**0.0360**
	25-May-05	Dup	**90.0**	**9.34**	0.400 U			0.200 U		0.600 U	**36.0**	**0.0260**
16EW14B	24-Mar-04	Primary	**10,000**			2.00 U		2.00 U		0.0500 U	**3,800**	1.00 U
	07-Apr-04	Primary	**228**		**1.41**			**0.340**	0.0300 U		**2,990**	
	21-Apr-04	Primary	**829**		0.0200 U			**1,040**	0.0300 U		**2,660**	
	21-Apr-04	Primary				2.00 U	**16.6**	**16.6**				1.00 U
	05-May-04	Primary	**903**		0.0200 U			0.0160 U	0.0300 U		**2,040**	
	20-May-04	Primary	**739**		0.0200 U			0.0160 U			**1,680**	
	20-May-04	Primary				2.00 U	**3.20**	**3.10**				0.100 U
	04-Jun-04	Primary	**664**		0.0200 U			0.200 U			**1,640**	
	17-Jun-04	Primary			0.0330 U			0.0330 U		0.0750 U	**1,770**	
	17-Jun-04	Dup			0.0330 U			0.0330 U		0.0750 U	**1,900**	
	07-Jul-04	Primary	**732**	**0.100**	0.400 U			0.200 U		0.600 U	**2,030**	
	04-Aug-04	Primary	**687**	**0.0580**	0.400 U			0.200 U		0.600 U	**2,260**	**0.0250**
	29-Sep-04	Primary	**723**	**0.280**	0.400 U			0.200 U	0.600 U		**2,280**	**0.0130**
	02-Dec-04	Primary	**0.591**									
	26-Jan-05	Primary	**576**	0.0800 U	0.400 U			0.200 U		0.600 U	**1,780**	**0.0780**
	10-Mar-05	Primary	**642**									
	25-May-05	Primary	**768**	0.0800 U	0.400 U			0.200 U		0.600 U	**2,410**	**0.0140**
16EW15	26-Jun-03	Primary	**673**			0.200 U		**7.13**			**5,490**	1.00 U
	26-Jun-03	Dup	**672**			0.200 U		**6.59**			**5,300**	1.00 U
	25-May-05	Primary	**642**	0.0800 U	0.400 U			0.200 U		0.600 U	**3,120**	**0.0270**
16PM01	26-Jun-03	Primary	**319**			0.200 U		**4.28**			**236**	2.50 U
	23-Mar-04	Primary	**435**			2.00 U		2.00 U		**0.370**	**206**	1.00 U
	06-Apr-04	Primary	**98.5**		0.0200 U			0.0160 U	0.0300 U		**1.07**	
	20-Apr-04	Primary	**380**		0.0200 U			0.0160 U	0.0300 U		**213**	
	20-Apr-04	Primary				2.00 U	**3.70**	**3.70**				1.00 U
	04-May-04	Primary	**418**		0.0200 U			0.0160 U	0.0300 U		**259**	
	18-May-04	Primary	**250**		0.0200 U			0.0160 U			**190**	
	18-May-04	Primary				0.200 U	**6.46**	**6.46**				0.100 U
	02-Jun-04	Primary	**304**		0.400 U			0.200 U			**267**	
	16-Jun-04	Primary			0.0330 U			0.0330 U		0.0750 U	**294**	
	04-Aug-04	Primary	**294**	**0.109**	0.400 U			0.200 U		0.600 U	**279**	**0.0230**
	04-Aug-04	Dup	**318**	**0.117**	0.400 U			0.200 U		0.600 U	**291**	**0.0100**
	30-Sep-04	Primary	**336**	**0.230**	0.400 U			0.200 U	0.600 U		**270**	**0.00400**
	01-Dec-04	Primary	**0.339**									
	26-Jan-05	Primary	**306**	**0.220**	0.400 U			0.200 U		0.600 U	**291**	**0.0110**
	26-Jan-05	Dup	**306**	**0.210**	0.400 U			0.200 U		0.600 U	**297**	**0.0360**
	10-Mar-05	Primary	**369**									
	24-May-05	Primary	**540**	**0.160**	0.400 U			0.200 U		0.600 U	**342**	**0.482**
16PM02	26-Jun-03	Primary	**470**			0.200 U		**0.670**			**334**	1.00 U
	23-Mar-04	Primary	**442**			2.00 U		2.00 U		**0.620**	**316**	1.00 U
	06-Apr-04	Primary	**294**		0.0200 U			0.0160 U	0.0300 U		**168**	
	20-Apr-04	Primary	**410**		0.0200 U			0.0160 U	0.0300 U		**331**	
	20-Apr-04	Primary				2.00 U	**4.70**	**4.70**				1.00 U
	04-May-04	Primary	**434**		0.0200 U			0.0160 U	0.0300 U		**358**	
	18-May-04	Primary	**283**		0.0200 U			0.0160 U			**260**	
	18-May-04	Primary				0.200 U	**2.54**	**2.54**				0.100 U
	02-Jun-04	Primary	**386**		0.400 U			0.200 U			**348**	
	16-Jun-04	Primary			0.0330 U			0.0330 U		0.0750 U	**350**	
	04-Aug-04	Primary	**474**	**0.0410**	0.400 U			0.200 U		0.600 U	**333**	**0.0200**

TABLE F-3: RESULTS OF ANIONS ANALYSIS.
Site 16 Landfill, LHAAP, Karnack, Texas

			Concentration (mg/L)									
Location	Date Sampled	Type	Chloride	Fluoride	Nitrate	Nitrate Nitrogen	Nitrate-Nitrite	Nitrite Nitrogen	Phosphate	Phosphorus	Sulfate	Sulfide
16PM02 Cont.	30-Sep-04	Primary	**495**	**0.140**	0.400 U			0.200 U	0.600 U		**312**	**0.0470**
	01-Dec-04	Primary	**0.489**									
	26-Jan-05	Primary	**564**	**0.0400**	0.400 U			0.200 U		0.600 U	**309**	**0.122**
	26-Jan-05	Dup	**603**	**0.0400**	0.400 U			0.200 U		0.600 U	**483**	**0.0840**
	10-Mar-05	Primary	**564**									
	24-May-05	Primary	**609**	**0.0800**	0.400 U			0.200 U		0.600 U	**489**	**0.0200**
16PM03	30-Jun-03	Primary	**524**			**2.24**		**1.17**			**496**	1.00 U
	23-Mar-04	Primary	**835**			**4.20**		2.00 U		**1.78**	**470**	1.00 U
	06-Apr-04	Primary	**372**		**7.83**			**0.250**	0.0300 U		**273**	
	20-Apr-04	Primary	**797**		**8,730**			**238**	0.0300 U		**535**	
	20-Apr-04	Primary				**4.90**	**14.8**	**9.90**				1.00 U
	04-May-04	Primary	**810**		**16.0**			**0.620**	0.0300 U		**642**	
	18-May-04	Primary	**483**		**14.0**			0.0160 U			**414**	
	18-May-04	Primary				**3.46**	**7.29**	**3.83**				0.100 U
	02-Jun-04	Primary	**585**		**14.6**			**0.660**			**493**	
	16-Jun-04	Primary			**13.5**			**0.568**		0.0750 U	**571**	
	04-Aug-04	Primary	**591**	**0.120**	**13.7**			**0.400**		0.600 U	**513**	**0.0260**
	30-Sep-04	Primary	**576**	**0.210**	**11.0**			**0.480**	0.600 U		**501**	**0.0120**
	01-Dec-04	Primary	**0.561**									
	26-Jan-05	Primary	**684**	**0.150**	**9.40**			**0.400**		0.600 U	**708**	**0.228**
	10-Mar-05	Primary	**714**									
	24-May-05	Primary	**585**	**0.160**	**5.99**			**0.220**		0.600 U	**573**	**0.0430**
	24-May-05	Dup	**480**	**0.180**	**6.22**			**0.200**		0.600 U	**540**	**0.0150**
16PM04	27-Jun-03	Primary	**491**			0.200 U		**0.930**			**621**	2.50 U
	23-Mar-04	Primary	**710**			2.00 U		2.00 U		**0.910**	**1,430**	1.00 U
	06-Apr-04	Primary	**416**		**0.0500**			0.0160 U	0.0300 U		**1,400**	
	20-Apr-04	Primary	**648**		0.0200 U			0.0160 U	0.0300 U		**2,750**	
	20-Apr-04	Primary				2.00 U	**57.4**	**57.4**				1.00 U
	04-May-04	Primary	**630**		0.0200 U			0.0160 U	0.0300 U		**2,330**	
	04-May-04	Dup	**651**		0.0200 U			0.0160 U	0.0300 U		**2,440**	
	18-May-04	Primary	**305**		0.0200 U			0.0160 U			**975**	
	18-May-04	Dup	**411**		0.0200 U			0.0160 U			**1,240**	
	18-May-04	Primary				0.200 U	**2.74**	**2.73**				0.100 U
	18-May-04	Dup				0.200 U	**7.03**	**7.03**				0.100 U
	03-Jun-04	Primary	**408**		0.400 U			0.200 U			**1,210**	
	16-Jun-04	Primary			0.0330 U			0.0330 U		0.0750 U	**1,370**	
	07-Jul-04	Primary	**465**	**0.920**	0.400 U			0.200 U		0.600 U	**1,520**	
	04-Aug-04	Primary	**423**	**0.110**	0.400 U			0.200 U		0.600 U	**1,520**	**0.0200**
	30-Sep-04	Primary	**471**	**0.150**	0.400 U			0.200 U	0.600 U		**1,170**	**0.0430**
	01-Dec-04	Primary	**0.417**									
	26-Jan-05	Primary	**486**	**0.200**	0.400 U			0.200 U		0.600 U	**1,580**	**0.0290**
	10-Mar-05	Primary	**561**									
	10-Mar-05	Dup	**561**									
	24-May-05	Primary	**540**	0.0800 U	0.400 U			0.200 U		0.600 U	**1,590**	**0.0420**
16PM05	26-Jun-03	Primary	**653**			0.200 U		**1.18**			**975**	2.50 U
	24-Mar-04	Primary	**1,590**			2.00 U		2.00 U		0.0500 U	**3,540**	1.00 U
	24-Mar-04	Dup	**1,220**			2.00 U		2.00 U		0.0500 U	**3,560**	1.00 U
	06-Apr-04	Primary	**519**		0.0200 U			0.0160 U	**0.0400**		**2,780**	
	20-Apr-04	Primary	**861**		0.0200 U			0.0160 U	0.0300 U		**5,430**	
	20-Apr-04	Primary				2.00 U	**11.5**	**11.5**				1.00 U
	04-May-04	Primary	**908**		0.0200 U			**0.0180**	0.0300 U		**5,350**	
	18-May-04	Primary	**515**		0.0200 U			0.0160 U			**3,010**	
	18-May-04	Primary				2.00 U	2.00 U	2.00 U				0.100 U
	02-Jun-04	Primary	**630**		0.400 U			0.200 U			**3,640**	
	16-Jun-04	Primary			0.0330 U			0.0330 U		0.0750 U	**3,820**	
	07-Jul-04	Primary	**690**	**0.120**	0.400 U			0.200 U		0.600 U	**4,030**	
	04-Aug-04	Primary	**639**	**0.0240**	0.400 U			0.200 U		0.600 U	**3,530**	**0.0410**
	29-Sep-04	Primary	**663**	**0.0800**	0.400 U			0.200 U	0.600 U		**3,830**	**0.0880**
	29-Sep-04	Dup	**657**	**0.100**	0.400 U			0.200 U	0.600 U		**3,850**	**0.125**

TABLE F-3: RESULTS OF ANIONS ANALYSIS.
Site 16 Landfill, LHAAP, Karnack, Texas

			Concentration (mg/L)									
Location	Date Sampled	Type	Chloride	Fluoride	Nitrate	Nitrate Nitrogen	Nitrate-Nitrite	Nitrite Nitrogen	Phosphate	Phosphorus	Sulfate	Sulfide
16PM05 Cont.	01-Dec-04	Primary	**0.630**									
	01-Dec-04	Dup	**0.645**									
	26-Jan-05	Primary	**699**	**0.0800**	0.400 U			0.200 U		0.600 U	**3,350**	**0.0460**
	10-Mar-05	Primary	**678**									
	24-May-05	Primary	**519**	**0.0900**	0.400 U			0.200 U		0.600 U	**2,490**	**0.0380**
16PM06	27-Jun-03	Primary	**315**			0.200 U		**0.760**			**395**	2.50 U
	23-Mar-04	Primary	**1,000**			2.00 U		2.00 U		**3.03**	**3,730**	1.00 U
	06-Apr-04	Primary	**963**		0.0200 U			0.0160 U	0.0300 U		**2,590**	
	20-Apr-04	Primary	**846**		0.0200 U			0.0160 U	0.0300 U		**5,320**	
	20-Apr-04	Primary				2.00 U	**10.8**	**10.8**				1.00 U
	04-May-04	Primary	**867**		**0.105**			0.0160 U	0.0300 U		**5,480**	
	19-May-04	Primary	**569**		0.0200 U			0.0160 U			**3,250**	
	19-May-04	Primary				2.00 U	2.00 U	2.00 U				0.100 U
	02-Jun-04	Primary	**603**		0.400 U			0.200 U			**3,360**	
	16-Jun-04	Primary			0.0330 U			0.0330 U		0.0750 U	**3,390**	
	07-Jul-04	Primary	**627**	**0.120**	0.400 U			0.200 U		0.600 U	**3,280**	
	04-Aug-04	Primary	**576**	**0.0660**	0.400 U			0.200 U		0.600 U	**2,990**	**0.0340**
	30-Sep-04	Primary	**552**	**0.140**	0.400 U			0.200 U	0.600 U		**2,560**	**0.0460**
	30-Sep-04	Dup	**543**	**0.140**	0.400 U			0.200 U	0.600 U		**2,550**	**0.0460**
	01-Dec-04	Primary	**0.498**									
	01-Dec-04	Dup	**0.492**									
	26-Jan-05	Primary	**567**	**0.0600**	0.400 U			0.200 U		0.600 U	**2,280**	**0.0480**
	10-Mar-05	Primary	**597**									
	24-May-05	Primary	**483**	**0.130**	**1.10**			0.200 U		0.600 U	**2,150**	**0.0760**
16PM07-D	27-Jun-03	Primary	**508**			**0.430**		**5.45**			**1,380**	2.50 U
	23-Mar-04	Primary	**821**			2.00 U		2.00 U		**0.620**	**837**	1.00 U
	07-Apr-04	Primary	**402**		0.0200 U			0.0160 U	0.0300 U		**580**	
	20-Apr-04	Primary	**608**		**30.0**			0.0160 U	0.0300 U		**995**	
	20-Apr-04	Primary				2.00 U	**7.20**	**7.20**				1.00 U
	04-May-04	Primary	**616**		0.0200 U			0.0160 U	0.0300 U		**1,170**	
	19-May-04	Primary	**382**		0.0200 U			0.0160 U			**693**	
	19-May-04	Primary				2.00 U	2.00 U	2.00 U				0.100 U
	03-Jun-04	Primary	**442**		0.400 U			0.200 U			**830**	
	16-Jun-04	Primary			0.0330 U			0.0330 U		0.0750 U	**1,230**	
	07-Jul-04	Primary	**510**	**0.220**	**0.190**			0.200 U		0.600 U	**1,250**	
	04-Aug-04	Primary	**450**	**0.707**	0.400 U			0.200 U		0.600 U	**1,210**	**0.0170**
	30-Sep-04	Primary	**435**	**0.570**	0.400 U			0.200 U	0.600 U		**1,420**	**0.0230**
	01-Dec-04	Primary	**0.459**									
	26-Jan-05	Primary	**543**	**0.0600**	0.400 U			0.200 U		0.600 U	**2,280**	**0.0280**
	10-Mar-05	Primary	**582**									
	24-May-05	Primary	**645**	0.0800 U	0.400 U			0.200 U		0.600 U	**2,310**	**0.0530**
16PM07-S	27-Jun-03	Primary	**409**			0.200 U		**4.39**			**739**	2.50 U
	23-Mar-04	Primary	**743**			2.00 U		2.00 U		**0.990**	**810**	1.00 U
	06-Apr-04	Primary	**671**		**0.0500**			**0.0370**	0.0300 U		**1,380**	
	20-Apr-04	Primary	**627**		**60.0**			**18.0**	0.0300 U		**1,190**	
	20-Apr-04	Primary				2.00 U	**20.6**	**20.6**				1.00 U
	04-May-04	Primary	**674**		**0.0720**			**0.0690**	0.0300 U		**1,530**	
	19-May-04	Primary	**407**		0.0200 U			0.0160 U			**975**	
	19-May-04	Primary				2.00 U	2.00 U	2.00 U				0.100 U
	03-Jun-04	Primary	**465**		0.400 U			0.200 U			**1,070**	
	16-Jun-04	Primary			0.0330 U			0.0330 U		0.0750 U	**1,160**	
	07-Jul-04	Primary	**501**	**0.170**	0.400 U			0.200 U		0.600 U	**1,170**	
	04-Aug-04	Primary	**468**	**0.127**	0.400 U			0.200 U		0.600 U	**1,100**	**0.0200**
	30-Sep-04	Primary	**755**	**0.180**	0.400 U			0.200 U	0.600 U		**2,440**	**0.0380**
	01-Dec-04	Primary	**0.465**									
	26-Jan-05	Primary	**507**	**0.0900**	0.400 U			0.200 U		0.600 U	**1,420**	**0.0660**
	10-Mar-05	Primary	**480**									
	24-May-05	Primary	**552**	**0.150**	0.400 U			0.200 U		0.600 U	**1,560**	**0.0210**

TABLE F-3: RESULTS OF ANIONS ANALYSIS.
Site 16 Landfill, LHAAP, Karnack, Texas

			Concentration (mg/L)									
Location	Date Sampled	Type	Chloride	Fluoride	Nitrate	Nitrate Nitrogen	Nitrate-Nitrite	Nitrite Nitrogen	Phosphate	Phosphorus	Sulfate	Sulfide
16PM08	27-Jun-03	Primary	**596**			**0.460**		**0.910**			**997**	1.00 U
	27-Jun-03	Dup	**584**			**0.420**		**0.750**			**953**	1.00 U
	23-Mar-04	Primary	**1,030**			2.00 U		2.00 U		**0.220**	**1,040**	1.00 U
	07-Apr-04	Primary	**458**		**1.67**			**0.0400**	0.0300 U		**772**	
	07-Apr-04	Dup	**449**		**1.65**			**0.0200**	0.0300 U		**765**	
	21-Apr-04	Primary	**904**		**1,870**			**53.0**	0.0300 U		**1,540**	
	21-Apr-04	Primary				**3.20**	**14.1**	**10.9**				1.00 U
	05-May-04	Primary	**849**		**3.25**			**0.0730**	0.0300 U		**1,670**	
	19-May-04	Primary	**534**		**3.00**			0.0160 U			**975**	
	19-May-04	Primary				2.00 U	2.00 U	2.00 U				0.100 U
	03-Jun-04	Primary	**659**		**3.55**			0.200 U			**1,240**	
	16-Jun-04	Primary			**30.2**			0.0330 U		0.0750 U	**1,280**	
	07-Jul-04	Primary	**708**	**0.180**	**2.61**			0.200 U		0.600 U	**1,300**	
	07-Jul-04	Dup	**717**	**0.200**	**2.31**			0.200 U		0.600 U	**1,320**	
	04-Aug-04	Primary	**630**	**0.189**	**2.50**			0.200 U		0.600 U	**1,210**	**0.0190**
	30-Sep-04	Primary	**642**	**0.200**	**1.06**			0.200 U	0.600 U		**1,170**	**0.0630**
	01-Dec-04	Primary	**0.624**									
	26-Jan-05	Primary	**660**	**0.120**	**1.66**			0.200 U		0.600 U	**1,320**	**0.0850**
	10-Mar-05	Primary	**735**									
	10-Mar-05	Dup	**729**									
	24-May-05	Primary	**648**	**0.120**	**1.20**			0.200 U		0.600 U	**1,500**	**0.0610**
16PM09	26-Jun-03	Primary	**495**			0.200 U		**0.800**			**1,090**	2.50 U
	24-Mar-04	Primary	**1,920**			2.00 U		2.00 U		0.0500 U	**2,070**	1.00 U
	06-Apr-04	Primary	**290**		**0.670**			0.0160 U	0.0300 U		**1,620**	
	20-Apr-04	Primary	**555**		0.0200 U			0.0160 U	0.0300 U		**3,270**	
	20-Apr-04	Primary				2.00 U	**13.0**	**13.0**				1.00 U
	04-May-04	Primary	**115**		**0.0670**			0.0160 U	0.0300 U		**3,300**	
	18-May-04	Primary	**585**		0.0200 U			0.0160 U			**1,590**	
	18-May-04	Primary				2.00 U	2.00 U	2.00 U				0.100 U
	02-Jun-04	Primary	**768**		0.400 U			0.200 U			**1,940**	
	02-Jun-04	Dup	**718**		0.400 U			0.200 U			**1,850**	
	16-Jun-04	Primary			0.0330 U			0.0330 U		0.0750 U	**1,910**	
	07-Jul-04	Primary	**762**	**0.170**	0.400 U			0.200 U		0.600 U	**1,710**	
	04-Aug-04	Primary	**642**	**0.0750**	0.400 U			0.200 U		0.600 U	**1,590**	**0.0210**
	29-Sep-04	Primary	**1,140**	**0.130**	0.400 U			0.200 U	0.600 U		**5,030**	**0.0750**
	01-Dec-04	Primary	**0.627**									
	26-Jan-05	Primary	**693**	**0.120**	0.400 U			0.200 U		0.600 U	**1,600**	**0.0150**
	10-Mar-05	Primary	**690**									
	24-May-05	Primary	**435**	**0.100**	0.400 U			0.200 U		0.600 U	**1,520**	**0.0410**
16PM10-D	27-Jun-03	Primary	**654**			0.200 U		**1.04**			**1,210**	2.50 U
	24-Mar-04	Primary	**1,610**			2.00 U		2.00 U		0.0500 U	**965**	1.00 U
	06-Apr-04	Primary	**762**		**0.0130**			**0.0290**	0.0300 U		**1,400**	
	21-Apr-04	Primary	**793**		0.0200 U			0.0160 U	0.0300 U		**1,230**	
	21-Apr-04	Primary				2.00 U	**8.60**	**8.60**				1.00 U
	04-May-04	Primary	**824**		0.0200 U			**0.0310**	0.0300 U		**1,560**	
	19-May-04	Primary	**489**		0.0200 U			0.0160 U			**885**	
	19-May-04	Primary				2.00 U	2.00 U	2.00 U				0.100 U
	03-Jun-04	Primary	**575**		0.400 U			0.200 U			**1,070**	
	17-Jun-04	Primary			0.0330 U			0.0330 U		0.0750 U	**1,290**	
	07-Jul-04	Primary	**645**	**0.100**	0.400 U			0.200 U		0.600 U	**1,540**	
	04-Aug-04	Primary	**552**	**0.0540**	0.400 U			0.200 U		0.600 U	**1,540**	**0.0180**
	30-Sep-04	Primary	**543**	**0.100**	0.400 U			0.200 U	0.600 U		**2,050**	**0.0740**
	01-Dec-04	Primary	**0.558**									
	26-Jan-05	Primary	**639**	**0.0400**	0.400 U			0.200 U		0.600 U	**1,930**	**0.0460**
	10-Mar-05	Primary	**672**									
	24-May-05	Primary	**627**	0.0800 U	0.400 U			0.200 U		0.600 U	**1,820**	**0.0210**

TABLE F-3: RESULTS OF ANIONS ANALYSIS.
Site 16 Landfill, LHAAP, Karnack, Texas

			Concentration (mg/L)									
Location	Date Sampled	Type	Chloride	Fluoride	Nitrate	Nitrate Nitrogen	Nitrate-Nitrite	Nitrite Nitrogen	Phosphate	Phosphorus	Sulfate	Sulfide
16PM10-S	27-Jun-03	Primary	**243**			0.200 U		**3.23**			**402**	2.50 U
	24-Mar-04	Primary	**2,120**			2.00 U		2.00 U		0.0500 U	**3,410**	**1.10**
	06-Apr-04	Primary	**786**		**0.176**			**0.0190**	0.0300 U		0.0120 U	
	21-Apr-04	Primary	**828**		0.0200 U			0.0160 U	0.0300 U		**4,910**	
	21-Apr-04	Primary				2.00 U	**14.2**	**14.2**				1.00 U
	04-May-04	Primary	**779**		0.0200 U			0.0160 U	0.0300 U		**4,540**	
	19-May-04	Primary	**533**		0.0200 U			0.0160 U			**2,600**	
	19-May-04	Primary				2.00 U	2.00 U	2.00 U				0.100 U
	03-Jun-04	Primary	**616**		0.400 U			0.200 U			**3,130**	
	17-Jun-04	Primary			0.0330 U			0.0330 U		0.0750 U	**3,160**	
	07-Jul-04	Primary	**672**	**0.270**	0.400 U			0.200 U		0.600 U	**3,490**	
	04-Aug-04	Primary	**534**	**0.234**	0.400 U			0.200 U		0.600 U	**2,620**	**0.0270**
	30-Sep-04	Primary	**459**	**0.270**	0.400 U			0.200 U	0.600 U		**1,980**	**0.0570**
	01-Dec-04	Primary	**0.411**									
	26-Jan-05	Primary	**570**	**0.120**	0.400 U			0.200 U		0.600 U	**2,360**	**0.0290**
	10-Mar-05	Primary	**459**									
	24-May-05	Primary	**612**	**0.410**	**1.57**			0.200 U		0.600 U	**1,370**	**0.0190**
16PM11	27-Jun-03	Primary	**628**			**1.14**		**0.790**			**1,470**	1.00 U
	23-Mar-04	Primary	**912**			**2.80**		2.00 U		**0.950**	**1,100**	1.00 U
	07-Apr-04	Primary	**442**		**2.85**			**0.0600**	0.0300 U		**991**	
	07-Apr-04	Dup	**454**		**2.83**			**0.0700**	0.0300 U		**987**	
	21-Apr-04	Primary	**937**		**4,710**			**157**	0.0300 U		**2,510**	
	21-Apr-04	Primary				**4.30**	**14.3**	**10.0**				1.00 U
	04-May-04	Primary	**921**		**7.87**			**0.239**	0.0300 U		**2,380**	
	20-May-04	Primary	**603**		**6.30**			0.0160 U			**1,460**	
	20-May-04	Primary				**2.30**	**2.30**	2.00 U				0.100 U
	03-Jun-04	Primary	**645**		**7.79**			**0.230**			**1,630**	
	03-Jun-04	Dup	**634**		**7.76**			**0.210**			**1,610**	
	17-Jun-04	Primary			**40.1**			**0.153**		0.0750 U	**1,580**	
	07-Jul-04	Primary	**648**	**0.160**	**4.32**			**0.0900**		0.600 U	**1,520**	
	07-Jul-04	Dup	**657**	**0.180**	**4.79**			**0.0800**		0.600 U	**1,510**	
	04-Aug-04	Primary	**600**	**0.163**	**5.50**			0.200 U		0.600 U	**1,590**	**0.0150**
	30-Sep-04	Primary	**648**	0.0800 U	**2.15**			0.200 U	0.600 U		**1,880**	**0.0440**
	01-Dec-04	Primary	**0.519**									
	26-Jan-05	Primary	**516**	**0.110**	0.400 U			0.200 U		0.600 U	**1,150**	**0.0250**
	10-Mar-05	Primary	**621**									
	24-May-05	Primary	**648**	**0.110**	0.400 U			0.200 U		0.600 U	**1,870**	**0.0140**
16PM12	26-Jun-03	Primary	**481**			0.200 U		**0.830**			**3,100**	2.50 U
	24-Mar-04	Primary	**2,140**			2.00 U		2.00 U		0.0500 U	**4,090**	1.00 U
	06-Apr-04	Primary	**190**		0.0200 U			0.0160 U	0.0300 U		**0.480**	
	20-Apr-04	Primary	**711**		**42.0**			0.0160 U	0.0300 U		**4,930**	
	20-Apr-04	Primary				2.00 U	**9.20**	**9.20**				1.00 U
	04-May-04	Primary	**766**		**0.121**			0.0160 U	0.0300 U		**5,190**	
	04-May-04	Dup	**770**		**0.0900**			**0.0380**	0.0300 U		0.0120 U	
	18-May-04	Primary				2.00 U	2.00 U	2.00 U				0.100 U
	19-May-04	Primary	**508**		0.0200 U			0.0160 U			**3,200**	
	02-Jun-04	Primary	**555**		0.400 U			0.200 U			**3,560**	
	17-Jun-04	Primary			0.0330 U			0.0330 U		0.0750 U	**3,740**	
	07-Jul-04	Primary	**651**	**0.100**	0.400 U			0.200 U		0.600 U	**3,900**	
	04-Aug-04	Primary	**576**	**0.0600**	0.400 U			0.200 U		0.600 U	**3,790**	**0.0310**
	29-Sep-04	Primary	**932**	**0.0800**	0.400 U			0.200 U	0.600 U		**7,190**	**0.0260**
	01-Dec-04	Primary	**0.594**									
	26-Jan-05	Primary	**630**	**0.0700**	0.400 U			0.200 U		0.600 U	**3,620**	**0.0560**
	10-Mar-05	Primary	**672**									
	24-May-05	Primary	**540**	0.0800 U	0.400 U			0.200 U		0.600 U	**4,220**	**0.0340**
16PM13-D	27-Jun-03	Primary	**667**			0.200 U		**5.94**			**2,850**	2.50 U
	23-Mar-04	Primary	**683**			2.00 U		2.00 U		**0.540**	**2,460**	1.00 U
	07-Apr-04	Primary	**473**		**0.180**			0.0160 U	0.0300 U		**1,670**	
	21-Apr-04	Primary	**973**		**170**			0.0160 U	0.0300 U		**3,220**	
	21-Apr-04	Primary				2.00 U	**12.4**	**12.4**				1.00 U
	05-May-04	Primary	**987**		**0.187**			0.0160 U	0.0300 U		**3,390**	
	19-May-04	Primary	**609**		0.0200 U			0.0160 U			**1,910**	

TABLE F-3: RESULTS OF ANIONS ANALYSIS.
Site 16 Landfill, LHAAP, Karnack, Texas

			Concentration (mg/L)									
Location	Date Sampled	Type	Chloride	Fluoride	Nitrate	Nitrate Nitrogen	Nitrate-Nitrite	Nitrite Nitrogen	Phosphate	Phosphorus	Sulfate	Sulfide
16PM13-D	19-May-04	Primary				2.00 U	2.00 U	2.00 U				0.100 U
Cont.	03-Jun-04	Primary	**677**		0.400 U			0.200 U			**2,090**	
	17-Jun-04	Primary			**0.269**			0.0330 U		0.0750 U	**2,290**	
	07-Jul-04	Primary	**792**	**0.100**	**0.630**			**0.0100**		0.600 U	**2,610**	
	04-Aug-04	Primary	**669**	**0.0510**	**0.800**			0.200 U		0.600 U	**2,390**	**0.0190**
	30-Sep-04	Primary	**690**	0.0800 U	0.400 U			0.200 U	0.600 U		**2,500**	**0.0840**
	01-Dec-04	Primary	**0.642**									
	26-Jan-05	Primary	**660**	0.0800 U	0.400 U			0.200 U		0.600 U	**3,440**	**0.0550**
	10-Mar-05	Primary	**648**									
	24-May-05	Primary	**636**	0.0800 U	0.400 U			0.200 U		0.600 U	**2,990**	**0.0190**
16PM13-S	27-Jun-03	Primary	**463**			0.200 U		**0.640**			**973**	2.50 U
	23-Mar-04	Primary	**709**			2.00 U		2.00 U		**1.24**	**610**	**1.30**
	07-Apr-04	Primary	**422**		0.0200 U			0.0160 U	0.0300 U		**512**	
	21-Apr-04	Primary	**664**		**46.0**			**19.0**	0.0300 U		**1,130**	
	21-Apr-04	Primary				2.00 U	**6.00**	**6.00**				1.00 U
	05-May-04	Primary	**674**		**0.205**			**0.0610**	0.0300 U		**1,940**	
	19-May-04	Primary	**448**		0.0200 U			0.0160 U			**1,200**	
	19-May-04	Primary				2.00 U	2.00 U	2.00 U				0.100 U
	03-Jun-04	Primary	**531**		0.400 U			0.200 U			**1,420**	
	17-Jun-04	Primary			0.0330 U			0.0330 U		0.0750 U	**1,360**	
	07-Jul-04	Primary	**627**	**0.200**	**0.120**			**0.0300**		0.600 U	**1,530**	
	04-Aug-04	Primary	**552**	**0.0870**	0.400 U			0.200 U		0.600 U	**1,360**	**0.0310**
	30-Sep-04	Primary	**570**	**0.130**	0.400 U			0.200 U	0.600 U		**1,500**	**0.112**
	01-Dec-04	Primary	**0.543**									
	26-Jan-05	Primary	**573**	**0.0700**	0.400 U			0.200 U		0.600 U	**1,460**	**0.0500**
	10-Mar-05	Primary	**606**									
	24-May-05	Primary	**540**	**0.155**	**20.8**			0.200 U		0.600 U	**1,400**	**0.0410**
16PM14	27-Jun-03	Primary	**531**			**1.69**		**1.05**			**2,140**	1.00 U
	23-Mar-04	Primary	**975**			**6.20**		2.00 U		**1.48**	**3,000**	**1.20**
	23-Mar-04	Dup	**959**			**5.90**		2.00 U		**1.53**	**2,970**	1.00 U
	07-Apr-04	Primary	**217**		**7.11**			**0.0900**	0.0300 U		**2,060**	
	21-Apr-04	Primary	**822**		**6,490**			**75.0**	0.0300 U		**3,660**	
	21-Apr-04	Primary				**4.90**	**15.1**	**10.2**				1.00 U
	05-May-04	Primary	**842**		**13.9**			**0.177**	0.0300 U		**3,960**	
	19-May-04	Primary	**569**		**12.1**			0.0160 U			**2,620**	
	20-May-04	Primary				**3.50**	**3.50**	2.00 U				0.100 U
	03-Jun-04	Primary	**616**		**15.0**			**0.230**			**2,890**	
	17-Jun-04	Primary			**11.5**			**0.174**		0.0750 U	**2,730**	
	07-Jul-04	Primary	**708**	**0.130**	**11.8**			**0.120**		0.600 U	**3,090**	
	04-Aug-04	Primary	**618**	**0.0810**	**14.8**			0.200 U		0.600 U	**2,850**	**0.0210**
	30-Sep-04	Primary	**663**	**0.110**	**8.75**			0.200 U	0.600 U		**2,900**	**0.201**
	01-Dec-04	Primary	**0.627**									
	26-Jan-05	Primary	**669**	**0.0800**	**1.86**			**0.261**		0.600 U	**3,180**	**0.0270**
	10-Mar-05	Primary	**732**									
	24-May-05	Primary	**609**	0.0800 U	0.400 U			0.200 U		0.600 U	**3,060**	**0.0220**
16WW16	30-Jun-03	Primary	**837**			**0.210**		**1.17**			**1,260**	1.00 U

Note: Nitrate and Nitrite data from April 20-21, 2004 sampling event is considereed anamolous and is under review

TABLE F-4: RESULTS OF VOLATILE FATTY ACIDS ANALYSIS.
Site 16 Landfill, LHAAP, Karnack, Texas

			Concentration (mg/L)			
Location	Date Sampled	Type	Acetate	Formic Acid	Lactic Acid	Propionate
16EW09	24-Mar-04	Primary	**13.1**	12.0 U		3.00 U
	21-Apr-04	Primary	**19.0**	**32.0**		
	21-Apr-04	Dup	**25.0**	**13.0**		
	05-May-04	Primary	**29.3**	**19.0**		3.00 U
	20-May-04	Primary	**22.0**	12.0 U		3.00 U
	04-Jun-04	Primary	**93.4**	**31.7**		**65.3**
	04-Aug-04	Primary	**22.0**	**39.0**	5.00 U	5.00 U
	04-Aug-04	Dup	**25.0**	**40.0**	**10.4**	**9.60**
	29-Sep-04	Primary	**41.7**	**7.30**	**293**	5.00 U
	26-Jan-05	Primary	**102**	**61.3**	**27.0**	5.00 U
	25-May-05	Primary	**98.1**	5.00 U	5.00 U	5.00 U
	30-Jan-06	Primary	**295**	**83.5**	5.00 U	5.00 U
	09-May-06	Primary	**826**	**59.0**	**5.00**	**26.0**
16EW10	23-Mar-04	Primary	**111**	12.0 U		**11.3**
	21-Apr-04	Primary	**88.0**	**13.0**		
	21-Apr-04	Dup	**140**	12.0 U		
	05-May-04	Primary	**92.8**	12.0 U		**16.7**
	20-May-04	Primary	**75.0**	12.0 U		3.00 U
	20-May-04	Dup	**75.0**	12.0 U		3.00 U
	04-Jun-04	Primary	**137**	12.0 U		**59.2**
	07-Jul-04	Primary	**259**	**62.2**	5.00 U	5.00 U
	04-Aug-04	Primary	**49.0**	**20.0**	5.00 U	5.00 U
	29-Sep-04	Primary	**711**	5.00 U	**524**	5.00 U
	26-Jan-05	Primary	**302**	**86.9**	**13.2**	5.00 U
	25-May-05	Primary	**320**	5.00 U	5.00 U	5.00 U
	30-Jan-06	Primary	**211**	**36.1**	5.00 U	5.00 U
	09-May-06	Primary	**5.00**	5.00 U	5.00 U	**63.0**
16EW12B	24-Mar-04	Primary	12.5 U	12.0 U		3.00 U
	21-Apr-04	Primary	12.5 U	12.0 U		
	05-May-04	Primary	**738**	12.0 U		**341**
	20-May-04	Primary	**1,890**	12.0 U		**1,600**
	04-Jun-04	Primary	**3,310**	12.0 U		**1,560**
	07-Jul-04	Primary	**2,800**	**34.7**	5.00 U	**319**
	04-Aug-04	Primary	**1,230**	**19.9**	5.00 U	**170**
	29-Sep-04	Primary	**681**	**26.9**	5.00 U	**88.0**
	26-Jan-05	Primary	**21,000**	5.00 U	**2,540**	**16.5**
	25-May-05	Primary	**2,750**	**28.0**	5.00 U	5.00 U
	30-Jan-06	Primary	**2,430**	**43.0**	5.00 U	**25.5**
	09-May-06	Primary	5.00 U	5.00 U	5.00 U	5.00 U

TABLE F-4: RESULTS OF VOLATILE FATTY ACIDS ANALYSIS.
Site 16 Landfill, LHAAP, Karnack, Texas

			Concentration (mg/L)			
Location	Date Sampled	Type	Acetate	Formic Acid	Lactic Acid	Propionate
16EW14B	24-Mar-04	Primary	12.5 U	12.0 U		3.00 U
	21-Apr-04	Primary	**2,890**	12.0 U		
	05-May-04	Primary	**9,470**	12.0 U		**7,210**
	20-May-04	Primary	**12,100**	12.0 U		**7,180**
	04-Jun-04	Primary	**7,180**	**14.7**		**2,710**
	07-Jul-04	Primary	**2,010**	**96.9**	5.00 U	**105**
	04-Aug-04	Primary	**530**	5.00 U	5.00 U	5.00 U
	29-Sep-04	Primary	5.00 U	5.00 U	**57.0**	5.00 U
	26-Jan-05	Primary	**11,600**	5.00 U	**1,900**	**5.42**
	25-May-05	Primary	**421**	5.00 U	5.00 U	5.00 U
16PM01	23-Mar-04	Primary	12.5 U	12.0 U		3.00 U
	20-Apr-04	Primary	**6.00**	**9.00**		
	04-May-04	Primary	12.5 U	12.0 U		3.00 U
	18-May-04	Primary	12.5 U	12.0 U		3.00 U
	02-Jun-04	Primary	12.5 U	12.0 U		**58.0**
	04-Aug-04	Primary	**0.700**	5.00 U	5.00 U	5.00 U
	04-Aug-04	Dup	5.00 U	**7.30**	5.00 U	5.00 U
	30-Sep-04	Primary	5.00 U	**17.5**	5.00 U	5.00 U
	26-Jan-05	Primary	**40.2**	**18.8**	5.00 U	5.00 U
	26-Jan-05	Dup	**37.4**	**20.8**	**11.7**	5.00 U
	24-May-05	Primary	**25.3**	5.00 U	5.00 U	5.00 U
	31-Jan-06	Primary	**42.0**	**25.0**	5.00 U	5.00 U
	09-May-06	Primary	**23.0**	**21.0**	5.00 U	**65.0**
16PM02	23-Mar-04	Primary	12.5 U	12.0 U		3.00 U
	20-Apr-04	Primary	12.5 U	**10.0**		
	04-May-04	Primary	12.5 U	12.0 U		**5.40**
	18-May-04	Primary	12.5 U	12.0 U		3.00 U
	02-Jun-04	Primary	12.5 U	12.0 U		**71.5**
	04-Aug-04	Primary	5.00 U	5.00 U	5.00 U	**19.0**
	30-Sep-04	Primary	5.00 U	5.00 U	**12.0**	5.00 U
	26-Jan-05	Primary	**9.00**	**6.20**	**14.9**	5.00 U
	26-Jan-05	Dup	**7.20**	**6.50**	**10.9**	5.00 U
	24-May-05	Primary	5.00 U	5.00 U	5.00 U	5.00 U
	31-Jan-06	Primary	**7.00**	5.00 U	5.00 U	5.00 U
	09-May-06	Primary	**45.0**	**16.0**	5.00 U	**63.0**
16PM03	23-Mar-04	Primary	12.5 U	12.0 U		3.00 U
	20-Apr-04	Primary	12.5 U	**1.00**		
	04-May-04	Primary	12.5 U	12.0 U		**18.5**
	18-May-04	Primary	12.5 U	12.0 U		3.00 U
	02-Jun-04	Primary	12.5 U	12.0 U		**70.7**
	04-Aug-04	Primary	5.00 U	5.00 U	5.00 U	**12.5**
	30-Sep-04	Primary	5.00 U	5.00 U	5.00 U	5.00 U
	26-Jan-05	Primary	**8.90**	**5.10**	5.00 U	5.00 U
	24-May-05	Primary	5.00 U	5.00 U	5.00 U	5.00 U
	24-May-05	Dup	5.00 U	5.00 U	5.00 U	5.00 U
	31-Jan-06	Primary	**153**	**14.5**	5.00 U	5.00 U
	31-Jan-06	Dup	**158**	**13.5**	5.00 U	5.00 U
	09-May-06	Primary	**448**	**58.0**	5.00 U	**83.0**

TABLE F-4: RESULTS OF VOLATILE FATTY ACIDS ANALYSIS.
Site 16 Landfill, LHAAP, Karnack, Texas

			Concentration (mg/L)			
Location	Date Sampled	Type	Acetate	Formic Acid	Lactic Acid	Propionate
16PM04	23-Mar-04	Primary	**13.1**	12.0 U		3.00 U
	20-Apr-04	Primary	**22.0**	12.0 U		
	04-May-04	Primary	**40.0**	12.0 U		3.00 U
	04-May-04	Dup	**28.0**	12.0 U		**3.30**
	18-May-04	Primary	**76.0**	12.0 U		3.00 U
	18-May-04	Dup	**70.0**	12.0 U		3.00 U
	03-Jun-04	Primary	**144**	12.0 U		**76.4**
	07-Jul-04	Primary	**204**	**35.8**	5.00 U	**48.2**
	04-Aug-04	Primary	**49.0**	**6.10**	5.00 U	5.00 U
	30-Sep-04	Primary	**15.8**	**9.70**	5.00 U	5.00 U
	26-Jan-05	Primary	**140**	**38.2**	**8.60**	5.00 U
	24-May-05	Primary	**82.5**	5.00 U	5.00 U	5.00 U
	30-Jan-06	Primary	**3,160**	**68.0**	5.00 U	5.00 U
	08-May-06	Primary	**252**	**95.0**	**8.00**	**54.0**
16PM05	24-Mar-04	Primary	12.5 U	12.0 U		3.00 U
	24-Mar-04	Dup	**13.1**	12.0 U		3.00 U
	20-Apr-04	Primary	**1,040**	12.0 U		
	04-May-04	Primary	**63.0**	12.0 U		3.00 U
	18-May-04	Primary	**36.0**	**27.0**		3.00 U
	02-Jun-04	Primary	**118**	12.0 U		**42.0**
	07-Jul-04	Primary	**357**	**130**	5.00 U	**31.2**
	04-Aug-04	Primary	**28.0**	**40.0**	5.00 U	5.00 U
	29-Sep-04	Primary	**715**	**186**	**580**	5.00 U
	29-Sep-04	Dup	**753**	**180**	**564**	5.00 U
	26-Jan-05	Primary	**418**	**108**	**30.0**	5.00 U
	24-May-05	Primary	**256**	5.00 U	5.00 U	5.00 U
	30-Jan-06	Primary	**450**	**109**	5.00 U	5.00 U
	08-May-06	Primary	**4.50**	**4.00**	5.00 U	**13.0**
	08-May-06	Dup	**7.50**	**8.00**	5.00 U	**14.0**
16PM06	23-Mar-04	Primary	12.5 U	12.0 U		3.00 U
	20-Apr-04	Primary	**3,350**	**59.0**		
	04-May-04	Primary	**2,430**	12.0 U		3.00 U
	19-May-04	Primary	**643**	**25.0**		3.00 U
	02-Jun-04	Primary	**326**	12.0 U		**5.60**
	07-Jul-04	Primary	**627**	**140**	5.00 U	5.00 U
	04-Aug-04	Primary	**41.3**	**53.7**	5.00 U	5.00 U
	30-Sep-04	Primary	**152**	**82.4**	**480**	5.00 U
	30-Sep-04	Dup	**249**	**110**	**478**	5.00 U
	26-Jan-05	Primary	**1,250**	**64.1**	**9.30**	5.00 U
	24-May-05	Primary	**162**	5.00 U	5.00 U	5.00 U
	30-Jan-06	Primary	**160**	**54.0**	5.00 U	5.00 U
	08-May-06	Primary	**149**	**64.0**	5.00 U	5.00 U
16PM07-D	23-Mar-04	Primary	**62.3**	12.0 U		**11.3**
	20-Apr-04	Primary	**136**	**13.0**		
	04-May-04	Primary	**40.0**	12.0 U		3.00 U
	19-May-04	Primary	**43.0**	12.0 U		**22.0**
	03-Jun-04	Primary	12.5 U	12.0 U		3.00 U
	07-Jul-04	Primary	**121**	**24.0**	5.00 U	5.00 U
	04-Aug-04	Primary	**32.0**	5.00 U	**31.0**	5.00 U
	30-Sep-04	Primary	5.00 U	**8.50**	**391**	5.00 U
	26-Jan-05	Primary	**157**	**31.4**	**14.0**	5.00 U
	24-May-05	Primary	**197**	5.00 U	5.00 U	5.00 U
	30-Jan-06	Primary	**430**	**18.0**	5.00 U	5.00 U
	08-May-06	Primary	**402**	**103**	5.00 U	5.00 U

TABLE F-4: RESULTS OF VOLATILE FATTY ACIDS ANALYSIS.
Site 16 Landfill, LHAAP, Karnack, Texas

			Concentration (mg/L)			
Location	Date Sampled	Type	Acetate	Formic Acid	Lactic Acid	Propionate
16PM07-S	23-Mar-04	Primary	**45.9**	12.0 U		3.00 U
	20-Apr-04	Primary	**108**	**7.00**		
	04-May-04	Primary	**49.0**	12.0 U		3.00 U
	19-May-04	Primary	**40.0**	12.0 U		3.00 U
	03-Jun-04	Primary	**70.0**	12.0 U		**39.6**
	07-Jul-04	Primary	**113**	**32.4**	5.00 U	5.00 U
	04-Aug-04	Primary	**13.0**	5.00 U	5.00 U	**2.90**
	30-Sep-04	Primary	**57.2**	5.00 U	**331**	5.00 U
	26-Jan-05	Primary	**109**	**13.8**	**6.10**	5.00 U
	24-May-05	Primary	**134**	5.00 U	5.00 U	5.00 U
	30-Jan-06	Primary	**320**	**50.0**	5.00 U	5.00 U
	08-May-06	Primary	**145**	**48.0**	5.00 U	5.00 U
16PM08	23-Mar-04	Primary	**13.1**	12.0 U		3.00 U
	21-Apr-04	Primary	**60.0**	**6.00**		
	05-May-04	Primary	**23.0**	12.0 U		3.00 U
	19-May-04	Primary	**33.0**	12.0 U		3.00 U
	03-Jun-04	Primary	12.5 U	12.0 U		3.00 U
	07-Jul-04	Primary	**77.2**	**7.30**	5.00 U	5.00 U
	07-Jul-04	Dup	**60.9**	**9.20**	5.00 U	**8.30**
	04-Aug-04	Primary	5.00 U	5.00 U	5.00 U	5.00 U
	30-Sep-04	Primary	**45.0**	**8.00**	5.00 U	5.00 U
	26-Jan-05	Primary	**66.7**	5.00 U	**5.30**	5.00 U
	24-May-05	Primary	**75.7**	5.00 U	5.00 U	5.00 U
	31-Jan-06	Primary	**2,150**	**80.0**	5.00 U	**9.50**
	09-May-06	Primary	5.00 U	5.00 U	5.00 U	5.00 U
16PM09	24-Mar-04	Primary	**144**	12.0 U		3.00 U
	20-Apr-04	Primary	**53.0**	ND		
	04-May-04	Primary	**126**	12.0 U		3.00 U
	18-May-04	Primary	12.5 U	12.0 U		3.00 U
	02-Jun-04	Primary	**37.4**	12.0 U		**70.7**
	02-Jun-04	Dup	**42.0**	12.0 U		**67.0**
	07-Jul-04	Primary	**76.8**	**16.0**	5.00 U	5.00 U
	04-Aug-04	Primary	**3.00**	5.00 U	5.00 U	**4.00**
	29-Sep-04	Primary	**76.8**	**19.4**	**23.0**	5.00 U
	26-Jan-05	Primary	**113**	**21.2**	**8.60**	5.00 U
	24-May-05	Primary	**129**	5.00 U	5.00 U	5.00 U
	30-Jan-06	Primary	**51.0**	**8.00**	5.00 U	5.00 U
	08-May-06	Primary	**25.0**	**41.0**	5.00 U	**28.0**
16PM10-D	24-Mar-04	Primary	**45.9**	12.0 U		**11.3**
	21-Apr-04	Primary	**101**	**7.00**		
	04-May-04	Primary	**32.5**	12.0 U		3.00 U
	19-May-04	Primary	**25.0**	12.0 U		3.00 U
	03-Jun-04	Primary	**61.6**	12.0 U		**73.8**
	07-Jul-04	Primary	**75.3**	**24.2**	5.00 U	5.00 U
	04-Aug-04	Primary	**5.10**	5.00 U	5.00 U	**13.0**
	30-Sep-04	Primary	**20.1**	**28.9**	**542**	5.00 U
	26-Jan-05	Primary	**200**	**77.5**	**14.5**	5.00 U
	24-May-05	Primary	**202**	5.00 U	5.00 U	5.00 U
	30-Jan-06	Primary	**350**	**45.0**	5.00 U	**5.50**
	30-Jan-06	Dup	**389**	**47.0**	5.00 U	**7.50**
	08-May-06	Primary	**211**	**96.0**	**5.00**	5.00 U

TABLE F-4: RESULTS OF VOLATILE FATTY ACIDS ANALYSIS.
Site 16 Landfill, LHAAP, Karnack, Texas

			Concentration (mg/L)			
Location	Date Sampled	Type	Acetate	Formic Acid	Lactic Acid	Propionate
16PM10-S	24-Mar-04	Primary	12.5 U	12.0 U		3.00 U
	21-Apr-04	Primary	**1,300**	12.0 U		
	04-May-04	Primary	**967**	12.0 U		3.00 U
	19-May-04	Primary	**67.0**	**27.0**		3.00 U
	03-Jun-04	Primary	**250**	12.0 U		**53.3**
	07-Jul-04	Primary	**754**	**160**	5.00 U	**10.1**
	04-Aug-04	Primary	**63.0**	**35.0**	5.00 U	5.00 U
	30-Sep-04	Primary	**311**	**20.1**	5.00 U	5.00 U
	26-Jan-05	Primary	**1,330**	**41.8**	**10.7**	5.00 U
	24-May-05	Primary	**70.1**	**7.80**	5.00 U	5.00 U
	30-Jan-06	Primary	**95.0**	**23.0**	5.00 U	**11.0**
	08-May-06	Primary	**193**	**57.0**	**5.00**	5.00 U
16PM11	23-Mar-04	Primary	12.5 U	12.0 U		3.00 U
	21-Apr-04	Primary	**63.0**	**8.00**		
	04-May-04	Primary	**29.2**	12.0 U		**7.00**
	20-May-04	Primary	**33.0**	12.0 U		3.00 U
	03-Jun-04	Primary	**47.9**	12.0 U		**68.9**
	03-Jun-04	Dup	**66.7**	12.0 U		**81.3**
	07-Jul-04	Primary	**53.0**	**6.70**	5.00 U	5.00 U
	07-Jul-04	Dup	**48.8**	**7.70**	5.00 U	**12.8**
	04-Aug-04	Primary	**20.0**	5.00 U	5.00 U	5.00 U
	30-Sep-04	Primary	**65.1**	**8.00**	5.00 U	**32.8**
	26-Jan-05	Primary	**59.9**	**8.70**	5.00 U	5.00 U
	24-May-05	Primary	**122**	5.00 U	5.00 U	5.00 U
	31-Jan-06	Primary	**450**	**113**	5.00 U	**28.0**
	09-May-06	Primary	**52.0**	**19.0**	5.00 U	5.00 U
16PM12	24-Mar-04	Primary	12.5 U	12.0 U		3.00 U
	20-Apr-04	Primary	**14.0**	**8.00**		
	04-May-04	Primary	12.5 U	12.0 U		3.00 U
	04-May-04	Dup	12.5 U	12.0 U		3.00 U
	19-May-04	Primary	**19.0**	12.0 U		3.00 U
	02-Jun-04	Primary	**40.4**	12.0 U		**64.0**
	07-Jul-04	Primary	**49.7**	5.00 U	5.00 U	5.00 U
	04-Aug-04	Primary	5.00 U	5.00 U	5.00 U	**6.00**
	29-Sep-04	Primary	**25.3**	5.00 U	**472**	5.00 U
	26-Jan-05	Primary	**27.2**	**7.60**	**15.2**	5.00 U
	24-May-05	Primary	**48.6**	5.00 U	5.00 U	5.00 U
	30-Jan-06	Primary	**60.0**	**16.0**	5.00 U	5.00 U
	08-May-06	Primary	5.00 U	5.00 U	5.00 U	**24.5**
16PM13-D	23-Mar-04	Primary	**95.1**	12.0 U		**11.3**
	21-Apr-04	Primary	**207**	**8.00**		
	05-May-04	Primary	**85.7**	12.0 U		**10.9**
	19-May-04	Primary	**89.0**	12.0 U		**28.0**
	03-Jun-04	Primary	**158**	**15.8**		**77.2**
	07-Jul-04	Primary	**177**	**48.9**	5.00 U	5.00 U
	04-Aug-04	Primary	**30.0**	5.00 U	5.00 U	**6.00**
	30-Sep-04	Primary	**64.5**	5.00 U	5.00 U	5.00 U
	26-Jan-05	Primary	**126**	**59.8**	**19.3**	5.00 U
	24-May-05	Primary	**260**	5.00 U	5.00 U	5.00 U
	30-Jan-06	Primary	**401**	**110**	5.00 U	5.00 U
	08-May-06	Primary	**223**	**150**	**9.00**	5.00 U

TABLE F-4: RESULTS OF VOLATILE FATTY ACIDS ANALYSIS.
Site 16 Landfill, LHAAP, Karnack, Texas

			Concentration (mg/L)			
Location	Date Sampled	Type	Acetate	Formic Acid	Lactic Acid	Propionate
16PM13-S	23-Mar-04	Primary	**21.3**	12.0 U		**11.3**
	21-Apr-04	Primary	**121**	**7.00**		
	05-May-04	Primary	**34.4**	12.0 U		3.00 U
	19-May-04	Primary	**25.0**	12.0 U		**12.0**
	03-Jun-04	Primary	**93.0**	**13.6**		**87.1**
	07-Jul-04	Primary	**122**	**45.8**	5.00 U	5.00 U
	04-Aug-04	Primary	**27.0**	5.00 U	5.00 U	5.00 U
	30-Sep-04	Primary	**76.9**	5.00 U	**311**	5.00 U
	26-Jan-05	Primary	**140**	**35.5**	**17.5**	5.00 U
	24-May-05	Primary	**111**	5.00 U	5.00 U	5.00 U
	30-Jan-06	Primary	**261**	**28.0**	5.00 U	5.00 U
	08-May-06	Primary	**217**	**106**	**6.00**	5.00 U
16PM14	23-Mar-04	Primary	**21.3**	12.0 U		3.00 U
	23-Mar-04	Dup	**29.5**	12.0 U		3.00 U
	21-Apr-04	Primary	**31.0**	**30.0**		
	05-May-04	Primary	**56.5**	12.0 U		**8.90**
	19-May-04	Primary	**31.0**	12.0 U		3.00 U
	03-Jun-04	Primary	**70.2**	12.0 U		**51.4**
	07-Jul-04	Primary	**93.7**	5.00 U	5.00 U	5.00 U
	04-Aug-04	Primary	**12.0**	**18.0**	5.00 U	5.00 U
	30-Sep-04	Primary	**57.1**	5.00 U	5.00 U	5.00 U
	26-Jan-05	Primary	**111**	**44.9**	**13.3**	5.00 U
	24-May-05	Primary	**221**	5.00 U	5.00 U	5.00 U
	31-Jan-06	Primary	**245**	**84.0**	5.00 U	5.00 U
	09-May-06	Primary	**302**	**117**	**12.0**	**18.0**

TABLE F-5
RESULTS OF PRIMARY METAL ANALYSIS.
Site 16 Landfill, LHAAP, Karnack, Texas

Location	Type	Date Sampled	Concentration (mg/L)					
			Arsenic	Arsenic, Total	Iron	Iron dissolved	Manganese	Manganese dissolved
16EW09	Primary	27-Mar-03	0.02 U		0.400 U		**5.38**	
	Primary	24-Mar-04			**22.6**	**0.984**	**9.41**	**8.89**
	Primary	21-Apr-04			**19.1**	**2.86**	**9.36**	**10.4**
	Duplicate	21-Apr-04			**8.37**	**1.17**	**9.12**	**10.1**
	Primary	20-May-04			**5**	**2.24**	**6.83**	**6.91**
	Primary	29-Sep-04			**22.5**	**4.92**	**9.11**	**7.5**
	Primary	02-Dec-04	0.01 U			**5.48**		**9.24**
	Primary	25-May-05		0.02 U	**3.61**		**6.6**	
	Primary	30-Jan-06		**0.02**	**86.1**		**11.2**	
	Primary	09-May-06		0.02 U	**12.1**		**10.1**	
16EW10	Primary	27-Mar-03	0.02 U		0.400 U		**2.27**	
	Primary	23-Mar-04			**18.4**	**1.89**	**3.05**	**2.8**
	Primary	21-Apr-04			**9.81**	**1.49**	**2.23**	**2.36**
	Duplicate	21-Apr-04			**10.6**	**1.25**	**2.34**	**2.4**
	Primary	20-May-04			**5.93**	**2.46**	**2.1**	**2.2**
	Duplicate	20-May-04			**7.21**	**2.25**	**2.18**	**2.03**
	Primary	29-Sep-04			**18**	**3.03**	**4.01**	**3.89**
	Primary	02-Dec-04	0.01 U			**16.4**		**3.59**
	Primary	25-May-05		0.02 U	**11.8**		**3.07**	
	Primary	30-Jan-06		0.02 U	**3.43**		**4.47**	
	Primary	09-May-06		0.02 U	**8.75**		**4.98**	
16EW11	Primary	27-Mar-03	0.02 U		0.40		**0.14**	
	Primary	25-May-05		0.02 U	**6.31**		**2.04**	
16EW12	Primary	30-Jun-03	0.02 U		**2.34**		**0.55**	
	Primary	25-May-05		0.02 U	**63.4**		**2.69**	
	Primary	30-Jan-06		**0.616**	**64.9**		**4.47**	
	Primary	09-May-06		**0.414**	**1.61**		**3.98**	
	Duplicate	09-May-06		**0.426**	**1.6**		**4.12**	
16EW12B	Primary	24-Mar-04			0.400 U	0.400 U	**1.31**	**1.16**
	Primary	21-Apr-04			**1.96**	**1.24**	**1.11**	**1.11**
	Primary	20-May-04			**6.04**	**6.55**	**0.981**	**0.96**
	Primary	29-Sep-04			**27.2**	**0.753**	**1.11**	**1.05**
	Primary	02-Dec-04	0.01 U			**23.2**		**1.06**
	Primary	25-May-05		0.02 U	**24.6**		**0.899**	
	Primary	30-Jan-06		**0.563**	**1.97**		**4.8**	
	Primary	09-May-06		**0.227**	**2.15**		**5.38**	
16EW13	Primary	26-Jun-03	0.02 U		**0.682**		**1.51**	
	Primary	25-May-05		**0.021**	**3.02**		**2.64**	
16EW14	Primary	26-Jun-03	0.02 U		**0.791**		**1.23**	
	Primary	25-May-05		**0.033**	**58.8**		**2.01**	
	Duplicate	25-May-05		**0.031**	**57.5**		**1.97**	
16EW14B	Primary	24-Mar-04			**0.729**	0.400 U	**6.11**	**6.08**
	Primary	21-Apr-04			**42**	**43.9**	**5.49**	**5.65**
	Primary	20-May-04			**61.9**	**5.48**	**5.41**	**5.32**
	Primary	29-Sep-04			**73.6**	**16.6**	**8.6**	**7.18**
	Primary	02-Dec-04	0.01 U			**49.6**		**8.17**
	Primary	25-May-05		0.02 U	**50**		**5.8**	
16EW15	Primary	26-Jun-03	0.02 U		0.400 U		**3.27**	
	Duplicate	26-Jun-03	0.02 U		0.400 U		**3.17**	
	Primary	25-May-05		**0.021**	**60**		**9.53**	

TABLE F-5
RESULTS OF PRIMARY METAL ANALYSIS.
Site 16 Landfill, LHAAP, Karnack, Texas

Location	Type	Date Sampled	Concentration (mg/L)					
			Arsenic	Arsenic, Total	Iron	Iron dissolved	Manganese	Manganese dissolved
16PM01	Primary	26-Jun-03	0.02 U		**1.1**		**1.01**	
	Primary	23-Mar-04			**15.8**	**7.28**	**1.44**	**1.38**
	Primary	20-Apr-04			**10.6**	**1.7**	**1.23**	**1.39**
	Primary	18-May-04			**10.2**	**2.55**	**1.38**	**1.4**
	Primary	28-Sep-04			**9.74**	**6.11**	**1.09**	**1.17**
	Primary	01-Dec-04	0.01 U			**10.8**		**1.27**
	Primary	24-May-05		0.02 U	**37**		**1.65**	
	Primary	31-Jan-06		0.02 U	**20.4**		**0.986**	
	Primary	09-May-06		0.02 U	**9.93**		**1.14**	
16PM02	Primary	26-Jun-03	0.02 U		**0.645**		**1.36**	
	Primary	23-Mar-04			**4.46**	**2.45**	**1.58**	**1.43**
	Primary	20-Apr-04			**3.74**	**2.19**	**1.74**	**1.7**
	Primary	18-May-04			**8.41**	**1.29**	**1.81**	**1.76**
	Primary	28-Sep-04			**5.33**	**1.78**	**2.12**	**1.71**
	Primary	01-Dec-04	0.01 U			**12.7**		**2.21**
	Primary	24-May-05		0.02 U	**16**		**2.75**	
	Primary	31-Jan-06		0.02 U	**16.8**		**2.01**	
	Primary	09-May-06		0.02 U	**3.34**		**2.03**	
16PM03	Primary	30-Jun-03	0.02 U		**1.26**		**0.298**	
	Primary	23-Mar-04			**4.67**	0.400 U	**0.266**	**0.259**
	Primary	20-Apr-04			**2.67**	0.400 U	**0.262**	**0.249**
	Primary	18-May-04			**0.893**	0.400 U	**0.189**	**0.197**
	Primary	28-Sep-04			**4.47**	0.400 U	**0.238**	**0.222**
	Primary	01-Dec-04	0.01 U			**18.9**		**0.238**
	Primary	24-May-05		0.02 U	**14.9**		**0.259**	
	Duplicate	24-May-05		0.02 U	**23.8**		**0.284**	
	Primary	31-Jan-06		0.02 U	**5.89**		**1.07**	
	Duplicate	31-Jan-06		0.02 U	**7.87**		**0.906**	
	Primary	09-May-06		0.02 U	**0.946**		**0.495**	
16PM04	Primary	27-Jun-03	0.02 U		0.400 U		**0.444**	
	Primary	23-Mar-04			**1.12**	0.400 U	**1.38**	**1.34**
	Primary	20-Apr-04			**0.717**	0.400 U	**1.7**	**1.63**
	Primary	18-May-04			**4.19**	0.400 U	**1.12**	**1.12**
	Duplicate	18-May-04			**2.69**	0.400 U	**1.15**	**1.09**
	Primary	28-Sep-04			**3.48**	**0.462**	**1.06**	**0.856**
	Primary	01-Dec-04	0.01 U			**2.56**		**0.957**
	Primary	24-May-05		0.02 U	**13.1**		**1.18**	
	Primary	30-Jan-06		0.02 U	**70.3**		**4.55**	
	Primary	08-May-06		0.02 U	**81.9**		**4.18**	
16PM05	Primary	26-Jun-03	0.02 U		0.400 U		**1.82**	
	Primary	24-Mar-04			**5.34**	0.400 U	**2.17**	**2.1**
	Duplicate	24-Mar-04			**4.21**	0.400 U	**2.3**	**2.19**
	Primary	20-Apr-04			**6.53**	**0.946**	**3.92**	**3.96**
	Primary	18-May-04			**18.9**	**2.49**	**5.4**	**6.98**
	Primary	29-Sep-04			**13.3**	**3.12**	**5.95**	**5.59**
	Duplicate	29-Sep-04			**12.8**	**3.69**	**7.6**	**7.33**
	Primary	01-Dec-04	0.01 U			**12.9**		**5.06**
	Duplicate	01-Dec-04	0.01 U			**12.6**		**5.1**
	Primary	24-May-05		0.02 U	**65.1**		**5.54**	
	Primary	30-Jan-06		**0.023**	**60.7**		**7.09**	
	Primary	08-May-06		0.02 U	**42.8**		**6.12**	
	Duplicate	08-May-06		0.02 U	**32.3**		**6.18**	

TABLE F-5
RESULTS OF PRIMARY METAL ANALYSIS.
Site 16 Landfill, LHAAP, Karnack, Texas

Location	Type	Date Sampled	Concentration (mg/L)					
			Arsenic	Arsenic, Total	Iron	Iron dissolved	Manganese	Manganese dissolved
16PM06	Primary	27-Jun-03	0.02 U		**0.918**		**1.71**	
	Primary	23-Mar-04			**29.7**	**4.23**	**8.33**	**7.89**
	Primary	20-Apr-04			**70.6**	**9.71**	**8.89**	**8.56**
	Primary	19-May-04			**126**	**8.26**	**7.66**	**7.59**
	Primary	28-Sep-04			**34.8**	**12.3**	**4.73**	**4.69**
	Duplicate	28-Sep-04			**47.5**	**12.9**	**5.33**	**4.74**
	Primary	01-Dec-04	0.01 U			**23.7**		**4.4**
	Duplicate	01-Dec-04	**0.01**			**23.9**		**4.01**
	Primary	24-May-05		0.02 U	**89.7**		**4.25**	
	Primary	30-Jan-06		**0.037**	**54.1**		**3.69**	
	Primary	08-May-06		0.02 U	**27.5**		**3.24**	
16PM07-D	Primary	27-Jun-03	0.02 U		0.400 U		**1.47**	
	Primary	23-Mar-04			**1.93**	0.400 U	**1.28**	**1.28**
	Primary	20-Apr-04			**2.03**	**0.432**	**1.3**	**1.19**
	Primary	19-May-04			**3.37**	**0.493**	**1.07**	**1.12**
	Primary	28-Sep-04			**5.35**	**2.07**	**1.48**	**1.45**
	Primary	01-Dec-04	0.01 U			**7.69**		**1.75**
	Primary	24-May-05		0.02 U	**21.3**		**2.55**	
	Primary	30-Jan-06		0.02 U	**17.7**		**2.37**	
	Primary	08-May-06		0.02 U	**18.7**		**2.24**	
16PM07-S	Primary	27-Jun-03	0.02 U		**1.49**		**1.29**	
	Primary	23-Mar-04			**3.74**	**0.458**	**0.834**	**0.826**
	Primary	20-Apr-04			**15.3**	0.400 U	**0.753**	**0.796**
	Primary	19-May-04			**2.07**	0.400 U	**0.842**	**0.806**
	Primary	28-Sep-04			**6.49**	**1.34**	**0.815**	**0.688**
	Primary	01-Dec-04	0.01 U			**7.25**		**0.876**
	Primary	24-May-05		0.02 U	**9.87**		**1.19**	
	Primary	30-Jan-06		**0.032**	**74.6**		**3.24**	
	Primary	08-May-06		0.02 U	**20**		**2.27**	
16PM08	Primary	27-Jun-03	0.02 U		0.400 U		**0.816**	
	Duplicate	27-Jun-03	0.02 U		0.400 U		**0.803**	
	Primary	23-Mar-04			**0.436**	0.400 U	**0.98**	**0.788**
	Primary	21-Apr-04			**0.951**	0.400 U	**0.833**	**0.793**
	Primary	19-May-04			**0.481**	0.400 U	**0.854**	**0.807**
	Primary	28-Sep-04			**3.06**	0.400 U	**0.886**	**0.74**
	Primary	01-Dec-04	0.01 U			**5.39**		**0.776**
	Primary	24-May-05		0.02 U	**7.19**		**0.875**	
	Primary	31-Jan-06		**0.087**	**134**		**17.7**	
	Primary	09-May-06		**0.039**	**105**		**18.4**	
16PM09	Primary	26-Jun-03	0.02 U		0.400 U		**2.51**	
	Primary	24-Mar-04			**1.19**	0.400 U	**4.41**	**4.26**
	Primary	20-Apr-04			**3.23**	0.400 U	**7.07**	**6.64**
	Primary	18-May-04			**3.27**	0.400 U	**11.1**	**8.58**
	Primary	29-Sep-04			**6.2**	**0.563**	**10.2**	**11.1**
	Primary	01-Dec-04	0.01 U			**7.17**		**7.09**
	Primary	24-May-05		0.02 U	**23.7**		**8.2**	
	Primary	30-Jan-06		0.02 U	**10.8**		**5.24**	
	Primary	08-May-06		0.02 U	**5.19**		**6.37**	

TABLE F-5
RESULTS OF PRIMARY METAL ANALYSIS.
Site 16 Landfill, LHAAP, Karnack, Texas

Location	Type	Date Sampled	Concentration (mg/L)					
			Arsenic	Arsenic, Total	Iron	Iron dissolved	Manganese	Manganese dissolved
16PM10-D	Primary	27-Jun-03	0.02 U		**2.26**		**4.57**	
	Primary	24-Mar-04			**7.44**	**4.12**	**3.68**	**3.59**
	Primary	21-Apr-04			**6.91**	**4.87**	**3.53**	**3.9**
	Primary	19-May-04			**6.75**	**4.67**	**3.79**	**3.41**
	Primary	28-Sep-04			**11.1**	**9.54**	**5.56**	**5.54**
	Primary	01-Dec-04	0.01 U			**11**		**5.22**
	Primary	24-May-05		0.02 U	**48.6**		**3.91**	
	Primary	30-Jan-06		0.02 U	**26.5**		**3.26**	
	Duplicate	30-Jan-06		0.02 U	**20.2**		**3.18**	
	Primary	08-May-06		0.02 U	**31**		**3.63**	
16PM10-S	Primary	27-Jun-03	0.02 U		0.400 U		**2**	
	Primary	24-Mar-04			**4.02**	0.400 U	**8.99**	**8.9**
	Primary	21-Apr-04			**9.77**	0.400 U	**24.8**	**30**
	Primary	19-May-04			**58.7**	0.400 U	**37.6**	**36.1**
	Primary	28-Sep-04			**71.2**	**10.7**	**11.8**	**11.9**
	Primary	01-Dec-04	**0.036**			**59.9**		**8.94**
	Primary	24-May-05		**0.06**	**134**		**9.08**	
	Primary	30-Jan-06		**0.056**	**90.5**		**4.39**	
	Primary	08-May-06		**0.06**	**98**		**5.89**	
16PM11	Primary	27-Jun-03	0.02 U		**4.3**		**1.28**	
	Primary	23-Mar-04			**1.1**	0.400 U	**1.58**	**1.17**
	Primary	21-Apr-04			**1.31**	0.400 U	**1.31**	**1.35**
	Primary	20-May-04			**0.573**	0.400 U	**1.22**	**1.21**
	Primary	28-Sep-04			**3.3**	0.400 U	**1.26**	**1.09**
	Primary	01-Dec-04	0.01 U			**4.23**		**0.988**
	Primary	24-May-05		0.02 U	**10.7**		**1.55**	
	Primary	31-Jan-06		**0.021**	**77.1**		**4.65**	
	Primary	09-May-06		0.02 U	**34.3**		**4.14**	
16PM12	Primary	26-Jun-03	0.02 U		0.400 U		**4.18**	
	Primary	24-Mar-04			**1.48**	**0.43**	**3.48**	**3.04**
	Primary	20-Apr-04			**1.3**	0.400 U	**4.17**	**4.36**
	Primary	18-May-04			**2.46**	**0.646**	**3.32**	**3.91**
	Primary	29-Sep-04			**2.75**	**0.758**	**4.31**	**4.11**
	Primary	01-Dec-04	0.01 U			**3.69**		**3.75**
	Primary	24-May-05		0.02 U	**4.17**		**4.3**	
	Primary	30-Jan-06		0.02 U	**2.92**		**4.18**	
	Primary	08-May-06		0.02 U	**0.745**		**4.19**	
16PM13-D	Primary	27-Jun-03	0.02 U		**2**		**4.83**	
	Primary	23-Mar-04			**2.47**	0.400 U	**4.02**	**4.02**
	Primary	21-Apr-04			**1.33**	0.400 U	**3.78**	**4.11**
	Primary	19-May-04			**1.18**	0.400 U	**3.52**	**3.51**
	Primary	28-Sep-04			**1.31**	0.400 U	**4.19**	**3.77**
	Primary	01-Dec-04	0.01 U			**3.11**		**4.48**
	Primary	24-May-05		0.02 U	**5.98**		**4.04**	
	Primary	30-Jan-06		0.02 U	**1.9**		**2.37**	
	Primary	08-May-06		0.02 U	**0.814**		**2.27**	

TABLE F-5
RESULTS OF PRIMARY METAL ANALYSIS.
Site 16 Landfill, LHAAP, Karnack, Texas

Location	Type	Date Sampled	Concentration (mg/L)					
			Arsenic	Arsenic, Total	Iron	Iron dissolved	Manganese	Manganese dissolved
16PM13-S	Primary	27-Jun-03	0.02 U		0.400 U		**2.23**	
	Primary	23-Mar-04			**2.68**	0.400 U	**0.952**	**0.886**
	Primary	21-Apr-04			**1.8**	0.400 U	**1.02**	**1.14**
	Primary	19-May-04			**1.29**	0.400 U	**2.05**	**2.07**
	Primary	28-Sep-04			**6.39**	0.400 U	**2.56**	**2.1**
	Primary	01-Dec-04	0.01 U			**6.24**		**2.18**
	Primary	24-May-05		0.02 U	**17.2**		**3.38**	
	Primary	30-Jan-06		0.02 U	**10.8**		**13**	
	Primary	08-May-06		0.02 U	**6.63**		**12.4**	
16PM14	Primary	27-Jun-03	0.02 U		0.400 U		**2.57**	
	Primary	23-Mar-04			**1.32**	0.400 U	**2.88**	**2.76**
	Duplicate	23-Mar-04			**1.86**	0.400 U	**2.92**	**2.63**
	Primary	21-Apr-04			**1.95**	0.400 U	**3.45**	**3.18**
	Primary	20-May-04			**2.1**	0.400 U	**3.17**	**2.98**
	Primary	28-Sep-04			**3.56**	0.400 U	**3**	**2.61**
	Primary	01-Dec-04	0.01 U			**2.53**		**2.69**
	Primary	24-May-05		0.02 U	**10.3**		**3.15**	
	Primary	31-Jan-06		0.02 U	**12.3**		**2.69**	
	Primary	09-May-06		0.02 U	**2**		**2.76**	
16WW16	Primary	30-Jun-03	0.02 U		**0.421**		**0.745**	

Notes:
mg/L - milligrams per liter
U - Non detects
All detects are in Bold

TABLE F-6
RESULTS OF SECONDARY METALS ANALYSIS.
Site 16 Landfill, LHAAP, Karnack, Texas

			Concentration (mg/L)									
Location	Date Sampled	Type	Antimony	Barium	Cadmium	Chromium	Lead	Nickel	Selenium	Silver	Thallium	Zinc
16EW09	27-Mar-03	Primary	0.0500 U	**0.058**	0.00500 U	0.01000 U	0.01000 U	**0.066**	0.0400 U	0.01000 U	0.0300 U	**0.063**
16EW09	02-Dec-04	Primary										
16EW10	27-Mar-03	Primary	0.0500 U	**0.123**	0.00500 U	0.01000 U	0.01000 U	**0.044**	0.0400 U	0.01000 U	0.0300 U	**0.045**
16EW10	02-Dec-04	Primary										
16EW11	27-Mar-03	Primary	0.0500 U	**0.057**	0.00500 U	0.01000 U	0.01000 U	0.0200 U	0.0400 U	0.01000 U	0.0300 U	**0.031**
16EW12	30-Jun-03	Primary	0.0500 U	**0.147**	0.00500 U	0.01000 U	0.01000 U	**0.036**	0.0400 U	0.01000 U	0.0300 U	**0.043**
16EW12B	02-Dec-04	Primary										
16EW13	26-Jun-03	Primary	0.0500 U	**0.068**	0.00500 U	0.01000 U	0.01000 U	**0.03**	0.0400 U	0.01000 U	0.0300 U	**0.041**
16EW14	26-Jun-03	Primary	0.0500 U	**0.348**	0.00500 U	0.01000 U	0.01000 U	0.0200 U	0.0400 U	0.01000 U	0.0300 U	0.0300 U
16EW14B	02-Dec-04	Primary										
16EW15	26-Jun-03	Primary	0.0500 U	**0.041**	0.00500 U	0.01000 U	0.01000 U	**0.067**	0.0400 U	0.01000 U	0.0300 U	**0.047**
16EW15	26-Jun-03	Dup	0.0500 U	**0.031**	0.00500 U	0.01000 U	0.01000 U	**0.067**	0.0400 U	0.01000 U	0.0300 U	**0.033**
16PM01	26-Jun-03	Primary	0.0500 U	**0.062**	0.00500 U	0.01000 U	0.01000 U	0.0200 U	0.0400 U	0.01000 U	0.0300 U	0.0300 U
16PM01	01-Dec-04	Primary										
16PM02	26-Jun-03	Primary	0.0500 U	**0.057**	0.00500 U	0.01000 U	0.01000 U	**0.03**	0.0400 U	0.01000 U	0.0300 U	0.0300 U
16PM02	01-Dec-04	Primary										
16PM03	30-Jun-03	Primary	0.0500 U	**0.07**	0.00500 U	0.01000 U	0.01000 U	0.0200 U	0.0400 U	0.01000 U	0.0300 U	0.0300 U
16PM03	01-Dec-04	Primary										
16PM04	27-Jun-03	Primary	0.0500 U	**0.064**	0.00500 U	0.01000 U	0.01000 U	0.0200 U	0.0400 U	0.01000 U	0.0300 U	0.0300 U
16PM04	01-Dec-04	Primary										
16PM05	26-Jun-03	Primary	0.0500 U	**0.055**	0.00500 U	0.01000 U	0.01000 U	**0.039**	0.0400 U	0.01000 U	0.0300 U	0.0300 U
16PM05	01-Dec-04	Primary										
16PM05	01-Dec-04	Dup										
16PM06	27-Jun-03	Primary	0.0500 U	**0.046**	0.00500 U	0.01000 U	0.01000 U	**0.033**	0.0400 U	0.01000 U	0.0300 U	**0.03**
16PM06	01-Dec-04	Primary										
16PM06	01-Dec-04	Dup										
16PM07-D	27-Jun-03	Primary	0.0500 U	**0.047**	0.00500 U	0.01000 U	0.01000 U	**0.021**	0.0400 U	0.01000 U	0.0300 U	0.0300 U
16PM07-D	01-Dec-04	Primary										
16PM07-S	27-Jun-03	Primary	0.0500 U	**0.07**	0.00500 U	0.01000 U	0.01000 U	**0.023**	0.0400 U	0.01000 U	0.0300 U	0.0300 U
16PM07-S	01-Dec-04	Primary										
16PM08	27-Jun-03	Primary	0.0500 U	**0.078**	0.00500 U	0.01000 U	0.01000 U	0.0200 U	0.0400 U	0.01000 U	0.0300 U	**0.052**
16PM08	27-Jun-03	Dup	0.0500 U	**0.081**	0.00500 U	0.01000 U	0.01000 U	0.0200 U	0.0400 U	0.01000 U	0.0300 U	0.0300 U
16PM08	01-Dec-04	Primary										
16PM09	26-Jun-03	Primary	0.0500 U	**0.054**	0.00500 U	0.01000 U	0.01000 U	**0.05**	0.0400 U	0.01000 U	0.0300 U	0.0300 U
16PM09	01-Dec-04	Primary										
16PM10-D	27-Jun-03	Primary	0.0500 U	**0.038**	**0.005**	0.01000 U	0.01000 U	**0.072**	0.0400 U	0.01000 U	0.0300 U	**0.077**
16PM10-D	01-Dec-04	Primary										
16PM10-S	27-Jun-03	Primary	0.0500 U	**0.045**	0.00500 U	0.01000 U	0.01000 U	**0.026**	0.0400 U	0.01000 U	0.0300 U	0.0300 U
16PM10-S	01-Dec-04	Primary										
16PM11	27-Jun-03	Primary	0.0500 U	**0.077**	0.00500 U	0.01000 U	0.01000 U	**0.026**	0.0400 U	0.01000 U	0.0300 U	**0.049**
16PM11	01-Dec-04	Primary										
16PM12	26-Jun-03	Primary	0.0500 U	**0.039**	0.00500 U	0.01000 U	0.01000 U	**0.095**	0.0400 U	0.01000 U	0.0300 U	**0.051**
16PM12	01-Dec-04	Primary										
16PM13-D	27-Jun-03	Primary	0.0500 U	**0.047**	0.00500 U	0.01000 U	0.01000 U	**0.064**	0.0400 U	0.01000 U	0.0300 U	**0.046**
16PM13-D	01-Dec-04	Primary										
16PM13-S	27-Jun-03	Primary	0.0500 U	**0.044**	0.00500 U	0.01000 U	0.01000 U	**0.039**	0.0400 U	0.01000 U	0.0300 U	0.0300 U
16PM13-S	01-Dec-04	Primary										
16PM14	27-Jun-03	Primary	0.0500 U	**0.073**	0.00500 U	0.01000 U	0.01000 U	**0.04**	0.0400 U	0.01000 U	0.0300 U	0.0300 U
16PM14	01-Dec-04	Primary										
16WW16	30-Jun-03	Primary	0.0500 U	**0.039**	0.00500 U	0.01000 U	0.01000 U	**0.063**	0.0400 U	0.01000 U	0.0300 U	**0.031**

Notes:
mg/L - milligrams per liter
U - Non Detect
All detects are in Bold

TABLE F-7: RESULTS OF VOC ANALYSIS.
Site 16 Landfill, LHAAP, Karnack, Texas

			Concentration (mg/L)																			
Location	Date Sampled	Type	1,1,1-Trichloroethane	1,1,2,2-Tetrachloroethane	1,1,2-Trichloroethane	1,1-Dichloroethane	1,1-Dichloroethene	1,2-Dichloroethane	1,2-Dichloropropane	2-Butanone (MEK)	2-Butanone (MEK), TCLP	2-Hexanone	4-Methyl-2-pentanone	Acetone	Benzene	Bromodichloromethane	Bromoform	Bromomethane	Carbon disulfide	Carbon-tetrachloride	Chlorobenzene	Chloroethane
16EW09	27-Mar-03	Primary	0.00500 U	0.00500 U	**0.00600**	0.00500 U	**0.0700**	0.00500 U	0.00500 U		0.0100 U	0.0100 U	0.0100 U	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U
	24-Mar-04	Primary	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	1.00 U		1.00 U	1.00 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U
	21-Apr-04	Primary	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	2.00 U		2.00 U	2.00 U	2.00 U	1.00 U	1.00 U	1.00 U	2.00 U	1.00 U	1.00 U	1.00 U	2.00 U
	21-Apr-04	Dup	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	2.00 U		2.00 U	2.00 U	2.00 U	1.00 U	1.00 U	1.00 U	2.00 U	1.00 U	1.00 U	1.00 U	2.00 U
	20-May-04	Primary	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	1.00 U		1.00 U	1.00 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U
	29-Sep-04	Primary	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	1.00 U		1.00 U	1.00 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U
16EW10	27-Mar-03	Primary	0.00500 U	0.00500 U	**0.00500**	0.00500 U	**0.0990**	**0.0590**	0.00500 U		0.0100 U	0.0100 U	0.0100 U	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U
	23-Mar-04	Primary	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	2.50 U		2.50 U	2.50 U	2.50 U	1.00 U	1.00 U	1.00 U	2.50 U	1.00 U	1.00 U	1.00 U	2.50 U
	21-Apr-04	Primary	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	2.00 U		2.00 U	2.00 U	2.00 U	1.00 U	1.00 U	1.00 U	2.00 U	1.00 U	1.00 U	1.00 U	2.00 U
	21-Apr-04	Dup	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	2.00 U		2.00 U	2.00 U	2.00 U	1.00 U	1.00 U	1.00 U	2.00 U	1.00 U	1.00 U	1.00 U	2.00 U
	20-May-04	Primary	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	1.00 U		1.00 U	1.00 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U
	20-May-04	Dup	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	1.00 U		1.00 U	1.00 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U
	29-Sep-04	Primary	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	1.00 U		1.00 U	1.00 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U
16EW11	27-Mar-03	Primary	0.00500 U	0.00500 U	0.00500 U	0.00500 U	**0.0330**	**0.124**	0.00500 U		0.0100 U	0.0100 U	0.0100 U	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U
16EW12	30-Jun-03	Primary	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U		1.00 U	1.00 U	1.00 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U
16EW12B	24-Mar-04	Primary	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	1.00 U		1.00 U	1.00 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U
	21-Apr-04	Primary	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	2.00 U		2.00 U	2.00 U	2.00 U	1.00 U	1.00 U	1.00 U	2.00 U	1.00 U	1.00 U	1.00 U	2.00 U
	20-May-04	Primary	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	1.00 U		1.00 U	1.00 U	**1.30**	0.500 U	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U
	29-Sep-04	Primary	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	1.00 U		1.00 U	1.00 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U
16EW13	26-Jun-03	Primary	0.200 U	0.200 U	0.200 U	0.200 U	0.200 U	0.200 U	0.200 U		0.500 U	0.500 U	0.500 U	0.500 U	0.200 U	0.200 U	0.200 U	0.500 U	0.200 U	0.200 U	0.200 U	0.500 U
16EW14	26-Jun-03	Primary	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U		0.200 U	0.200 U	0.200 U	0.200 U	0.100 U	0.100 U	0.100 U	0.200 U	0.100 U	0.100 U	0.100 U	0.200 U
16EW14B	24-Mar-04	Primary	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	1.00 U		1.00 U	1.00 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U
	21-Apr-04	Primary	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	2.00 U		2.00 U	2.00 U	2.00 U	1.00 U	1.00 U	1.00 U	2.00 U	1.00 U	1.00 U	1.00 U	2.00 U
	20-May-04	Primary	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	1.00 U		1.00 U	1.00 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U
	29-Sep-04	Primary	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	1.00 U		1.00 U	1.00 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U
16EW15	26-Jun-03	Primary	0.00500 U	0.00500 U	0.00500 U	0.00500 U	**0.0340**	0.00500 U	0.00500 U		0.0100 U	0.0100 U	0.0100 U	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U
	26-Jun-03	Dup	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U		0.200 U	0.200 U	0.200 U	0.200 U	0.100 U	0.100 U	0.100 U	0.200 U	0.100 U	0.100 U	0.100 U	0.200 U
16PM01	26-Jun-03	Primary	0.100 U	0.100 U	0.100 U	0.100 U	**0.300**	0.100 U	0.100 U		0.200 U	0.200 U	0.200 U	0.200 U	0.100 U	0.100 U	0.100 U	0.200 U	0.100 U	0.100 U	0.100 U	0.200 U
	23-Mar-04	Primary	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	5.00 U		5.00 U	5.00 U	5.00 U	2.00 U	2.00 U	2.00 U	5.00 U	2.00 U	2.00 U	2.00 U	5.00 U
	20-Apr-04	Primary	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	2.00 U		2.00 U	2.00 U	2.00 U	1.00 U	1.00 U	1.00 U	2.00 U	1.00 U	1.00 U	1.00 U	2.00 U
	18-May-04	Primary	0.00500 U	0.00500 U	**0.0350**	**0.0290**	**0.500**	**0.0620**	0.00500 U	0.0100 U		0.0100 U	0.0100 U	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U
	28-Sep-04	Primary	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	1.00 U		1.00 U	1.00 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U
16PM02	26-Jun-03	Primary	0.100 U	0.100 U	0.100 U	0.100 U	**0.100**	**0.200**	0.100 U		0.200 U	0.200 U	0.200 U	0.200 U	0.100 U	0.100 U	0.100 U	0.200 U	0.100 U	0.100 U	0.100 U	0.200 U
	23-Mar-04	Primary	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	1.00 U		1.00 U	1.00 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U
	20-Apr-04	Primary	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	2.00 U		2.00 U	2.00 U	2.00 U	1.00 U	1.00 U	1.00 U	2.00 U	1.00 U	1.00 U	1.00 U	2.00 U
	18-May-04	Primary	0.00500 U	0.00500 U	**0.0150**	**0.00700**	**0.199**	**0.294**	0.00500 U	0.0100 U		0.0100 U	**0.0160**	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U
	28-Sep-04	Primary	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	1.00 U		1.00 U	1.00 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U
16PM03	30-Jun-03	Primary	0.500 U	0.500 U	0.500 U	0.500 U	**0.600**	0.500 U	0.500 U		1.00 U	1.00 U	1.00 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U
	23-Mar-04	Primary	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	5.00 U		5.00 U	5.00 U	5.00 U	2.00 U	2.00 U	2.00 U	5.00 U	2.00 U	2.00 U	2.00 U	5.00 U
	20-Apr-04	Primary	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	2.00 U		2.00 U	2.00 U	2.00 U	1.00 U	1.00 U	1.00 U	2.00 U	1.00 U	1.00 U	1.00 U	2.00 U
	18-May-04	Primary	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	1.00 U		1.00 U	1.00 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U
	28-Sep-04	Primary	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	1.00 U		1.00 U	1.00 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U
16PM04	27-Jun-03	Primary	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U		2.00 U	2.00 U	2.00 U	2.00 U	1.00 U	1.00 U	1.00 U	2.00 U	1.00 U	1.00 U	1.00 U	2.00 U
	23-Mar-04	Primary	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	2.50 U		2.50 U	2.50 U	2.50 U	1.00 U	1.00 U	1.00 U	2.50 U	1.00 U	1.00 U	1.00 U	2.50 U
	20-Apr-04	Primary	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	2.00 U		2.00 U	2.00 U	2.00 U	1.00 U	1.00 U	1.00 U	2.00 U	1.00 U	1.00 U	1.00 U	2.00 U
	18-May-04	Primary	0.00500 U	0.00500 U	**0.0270**	**0.0110**	**0.251**	**0.0950**	0.00500 U	0.0100 U		0.0100 U	**0.0150**	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U
	18-May-04	Dup	0.00500 U	0.00500 U	**0.0290**	**0.0120**	**0.292**	**0.101**	0.00500 U	0.0100 U		0.0100 U	**0.0150**	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U
	28-Sep-04	Primary	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	1.00 U		1.00 U	1.00 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U
16PM05	26-Jun-03	Primary	0.0200 U	0.0200 U	0.0200 U	0.0200 U	0.0200 U	0.0200 U	0.0200 U		0.0500 U	0.0500 U	0.0500 U	0.0500 U	0.0200 U	0.0200 U	0.0200 U	0.0500 U	0.0200 U	0.0200 U	0.0200 U	0.0500 U
	24-Mar-04	Primary	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	1.00 U		1.00 U	1.00 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U
	24-Mar-04	Dup	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	1.00 U		1.00 U	1.00 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U
	20-Apr-04	Primary	0.200 U	0.200 U	0.200 U	0.200 U	0.200 U	0.200 U	0.200 U	0.500 U		0.500 U	0.500 U	0.500 U	0.200 U	0.200 U	0.200 U	0.500 U	0.200 U	0.200 U	0.200 U	0.500 U
	18-May-04	Primary	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	1.00 U		1.00 U	1.00 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U
	29-Sep-04	Primary	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	1.00 U		1.00 U	1.00 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U
	29-Sep-04	Dup	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	1.00 U		1.00 U	1.00 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U
16PM06	27-Jun-03	Primary	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U		2.00 U	2.00 U	2.00 U	2.00 U	1.00 U	1.00 U	1.00 U	2.00 U	1.00 U	1.00 U	1.00 U	2.00 U
	23-Mar-04	Primary	0.200 U	0.200 U	0.200 U	0.200 U	0.200 U	0.200 U	0.200 U	0.500 U		0.500 U	0.500 U	0.500 U	0.200 U	0.200 U	0.200 U	0.500 U	0.200 U	0.200 U	0.200 U	0.500 U
	20-Apr-04	Primary	0.0500 U	0.0500 U	0.0500 U	0.0500 U	**0.140**	0.0500 U	0.0500 U	0.100 U		0.100 U	0.100 U	0.100 U	0.0500 U	0.0500 U	0.0500 U	0.100 U	0.0500 U	0.0500 U	0.0500 U	0.100 U
	19-May-04	Primary	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	1.00 U		1.00 U	1.00 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U
	28-Sep-04	Primary	0.100 U	0.100 U	0.100 U	0.100 U	**0.100**	0.100 U	0.100 U	0.200 U		0.200 U	0.200 U	0.200 U	0.100 U	0.100 U	0.100 U	0.200 U	0.100 U	0.100 U	0.100 U	0.200 U
	28-Sep-04	Dup	0.100 U	0.100 U	0.100 U	0.100 U	**0.100**	0.100 U	0.100 U	0.200 U		0.200 U	0.200 U	0.200 U	0.100 U	0.100 U	0.100 U	0.200 U	0.100 U	0.100 U	0.100 U	0.200 U

TABLE F-7: RESULTS OF VOC ANALYSIS.
Site 16 Landfill, LHAAP, Karnack, Texas

Location	Date Sampled	Type	Concentration (mg/L)																
			Chloroform	Chloromethane	cis/trans1,2-Dichloroethene	cis-1,2-Dichloroethene	cis-1,3-Dichloropropene	Dibromo-chloromethane	Dichloromethane (Methylene chloride)	Ethyl benzene	Styrene	Tetrachloroethene	Toluene	trans-1,2-Dichloroethene	trans-1,3-Dichloropropene	Trichloroethene	Trichloro-trifluoroethane	Vinyl chloride	Xylenes (unspecified)
16EW09	27-Mar-03	Primary	**0.0140**	0.0100 U	**0.934**	**0.900**	0.00500 U	0.00500 U	**0.590**	0.00500 U	0.00500 U	0.00500 U	0.00500 U	**0.00600**	0.00500 U	**60.0**	**0.600**	**0.0410**	0.0150 U
	24-Mar-04	Primary	0.500 U	1.00 U	**12.2**	**12.2**	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	**66.0**	**0.700**	1.00 U	1.50 U
	21-Apr-04	Primary	1.00 U	2.00 U	**3.76**	**4.00**	1.00 U	1.00 U	2.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	**73.0**	1.00 U	2.00 U	3.00 U
	21-Apr-04	Dup	1.00 U	2.00 U	**4.90**	**5.00**	1.00 U	1.00 U	2.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	**59.0**	1.00 U	2.00 U	3.00 U
	20-May-04	Primary	0.500 U	1.00 U	**4.02**	**4.00**	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	**45.0**	**0.500**	1.00 U	1.50 U
	29-Sep-04	Primary	0.500 U	1.00 U	**6.14**	**6.10**	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	**67.0**	**0.600**	1.00 U	1.50 U
16EW10	27-Mar-03	Primary	**0.0110**	0.0100 U	**26.8**	**27.0**	0.00500 U	0.00500 U	**0.0110**	0.00500 U	0.00500 U	0.00500 U	0.00500 U	**0.0310**	0.00500 U	**80.0**	0.200 U	**1.12**	0.0150 U
	23-Mar-04	Primary	1.00 U	2.50 U	**53.6**	**54.0**	1.00 U	1.00 U	2.50 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	**83.0**	1.00 U	2.50 U	3.80 U
	21-Apr-04	Primary	1.00 U	2.00 U	**47.2**	**47.0**	1.00 U	1.00 U	2.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	**103**	1.00 U	**2.90**	3.00 U
	21-Apr-04	Dup	1.00 U	2.00 U	**47.1**	**47.0**	1.00 U	1.00 U	2.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	**98.0**	1.00 U	**2.90**	3.00 U
	20-May-04	Primary	0.500 U	1.00 U	**46.6**	**47.0**	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	**93.0**	0.500 U	**1.40**	1.50 U
	20-May-04	Dup	0.500 U	1.00 U	**42.9**	**43.0**	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	**80.0**	0.500 U	**1.40**	1.50 U
	29-Sep-04	Primary	0.500 U	1.00 U	**44.5**	**44.0**	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	**36.0**	0.500 U	1.00 U	1.50 U
16EW11	27-Mar-03	Primary	0.00500 U	0.0100 U	**8.03**	**8.00**	0.00500 U	0.00500 U	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	**0.00700**	0.00500 U	**11.5**	**0.0180**	**0.430**	0.0150 U
16EW12	30-Jun-03	Primary	0.500 U	1.00 U	**199**	**200**	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	**19.7**	0.500 U	**5.00**	1.50 U
16EW12B	24-Mar-04	Primary	0.500 U	1.00 U	**64.5**	**64.0**	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	**23.0**	0.500 U	**2.90**	1.50 U
	21-Apr-04	Primary	1.00 U	2.00 U	**78.2**	**78.0**	1.00 U	1.00 U	2.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	**29.0**	1.00 U	**4.80**	3.00 U
	20-May-04	Primary	0.500 U	1.00 U	**66.3**	**66.0**	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	**18.0**	0.500 U	**2.50**	1.50 U
	29-Sep-04	Primary	0.500 U	1.00 U	**118**	**118**	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	**7.70**	0.500 U	**8.00**	1.50 U
16EW13	26-Jun-03	Primary	0.200 U	0.500 U	**23.7**	**20.0**	0.200 U	0.200 U	0.500 U	0.200 U	0.200 U	0.200 U	0.200 U	0.200 U	0.200 U	**160**	**0.700**	**0.810**	0.750 U
16EW14	26-Jun-03	Primary	0.100 U	0.200 U	**0.270**	**0.300**	0.100 U	0.100 U	0.200 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	**9.70**	0.100 U	0.200 U	0.300 U
16EW14B	24-Mar-04	Primary	0.500 U	1.00 U	**8.54**	**8.50**	0.500 U	0.500 U	**6.50**	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	**56.0**	**0.600**	1.00 U	1.50 U
	21-Apr-04	Primary	1.00 U	2.00 U	**17.6**	**18.0**	1.00 U	1.00 U	**4.30**	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	**50.0**	1.00 U	2.00 U	3.00 U
	20-May-04	Primary	0.500 U	1.00 U	**24.6**	**25.0**	0.500 U	0.500 U	**2.70**	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	**31.0**	0.500 U	1.00 U	1.50 U
	29-Sep-04	Primary	0.500 U	1.00 U	**16.0**	**16.0**	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	**27.0**	0.500 U	1.00 U	1.50 U
16EW15	26-Jun-03	Primary	0.00500 U	0.0100 U	**1.06**	**1.10**	0.00500 U	0.00500 U	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	**6.70**	**0.190**	**0.0600**	0.0150 U
	26-Jun-03	Dup	0.100 U	0.200 U	**1.03**	**1.00**	0.100 U	0.100 U	0.200 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	**5.20**	**0.300**	0.200 U	0.300 U
16PM01	26-Jun-03	Primary	0.100 U	0.200 U	**149**	**149**	0.100 U	0.100 U	0.200 U	0.100 U	0.100 U	0.100 U	0.100 U	**0.100**	0.100 U	**94.0**	**0.200**	**4.56**	0.300 U
	23-Mar-04	Primary	2.00 U	5.00 U	**183**	**180**	2.00 U	2.00 U	5.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	**110**	2.00 U	**7.40**	7.50 U
	20-Apr-04	Primary	1.00 U	2.00 U	**200**	**200**	1.00 U	1.00 U	2.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	**120**	1.00 U	**8.70**	3.00 U
	18-May-04	Primary	0.00500 U	0.0100 U	**187**	**190**	0.00500 U	0.00500 U	0.0100 U	**0.00500**	0.00500 U	0.00500 U	**0.0260**	**0.213**	0.00500 U	**92.0**	**0.270**	**5.30**	**0.0840**
	28-Sep-04	Primary	0.500 U	1.00 U	**196**	**200**	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	**80.0**	0.500 U	**6.60**	1.50 U
16PM02	26-Jun-03	Primary	0.100 U	0.200 U	**40.9**	**41.0**	0.100 U	0.100 U	**0.210**	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	**147**	**1.00**	**0.990**	0.300 U
	23-Mar-04	Primary	0.500 U	1.00 U	**41.9**	**42.0**	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	**150**	0.500 U	**2.60**	1.50 U
	20-Apr-04	Primary	1.00 U	2.00 U	**40.0**	**40.0**	1.00 U	1.00 U	2.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	**180**	**1.00**	**3.10**	3.00 U
	18-May-04	Primary	**0.0520**	0.0100 U	**36.9**	**37.0**	0.00500 U	0.00500 U	**0.718**	**0.0150**	0.00500 U	**0.0180**	**0.0160**	**0.0840**	0.00500 U	**137**	**0.900**	**1.50**	**0.0300**
	28-Sep-04	Primary	0.500 U	1.00 U	**27.0**	**27.0**	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	**137**	**0.700**	**1.20**	1.50 U
16PM03	30-Jun-03	Primary	0.500 U	1.00 U	**199**	**200**	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	**20.0**	0.500 U	**6.90**	1.50 U
	23-Mar-04	Primary	2.00 U	5.00 U	**206**	**206**	2.00 U	2.00 U	5.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	**41.0**	2.00 U	**10.6**	7.50 U
	20-Apr-04	Primary	1.00 U	2.00 U	**139**	**139**	1.00 U	1.00 U	2.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	**35.0**	1.00 U	**8.00**	3.00 U
	18-May-04	Primary	0.500 U	1.00 U	**61.5**	**62.0**	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	**11.0**	0.500 U	**4.50**	1.50 U
	28-Sep-04	Primary	0.500 U	1.00 U	**144**	**140**	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	**30.0**	0.500 U	**4.90**	1.50 U
16PM04	27-Jun-03	Primary	1.00 U	2.00 U	**139**	**140**	1.00 U	1.00 U	2.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	**50.0**	1.00 U	**4.10**	3.00 U
	23-Mar-04	Primary	1.00 U	2.50 U	**97.5**	**98.0**	1.00 U	1.00 U	2.50 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	**96.0**	1.00 U	**4.20**	3.80 U
	20-Apr-04	Primary	1.00 U	2.00 U	**52.1**	**52.0**	1.00 U	1.00 U	**2.20**	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	**102**	1.00 U	**2.90**	3.00 U
	18-May-04	Primary	**0.0150**	0.0100 U	**70.6**	**70.0**	0.00500 U	0.00500 U	**0.973**	0.00500 U	0.00500 U	0.00500 U	**0.0100**	**0.118**	0.00500 U	**92.0**	**0.432**	**1.80**	**0.0360**
	18-May-04	Dup	**0.0150**	0.0100 U	**70.0**	**70.0**	0.00500 U	0.00500 U	**0.923**	0.00500 U	0.00500 U	0.00500 U	**0.0110**	**0.121**	0.00500 U	**93.0**	**0.518**	**1.90**	**0.0390**
	28-Sep-04	Primary	0.500 U	1.00 U	**67.0**	**70.0**	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	**130**	0.500 U	**2.80**	1.50 U
16PM05	26-Jun-03	Primary	0.0200 U	0.0500 U	**0.784**	**0.780**	0.0200 U	0.0200 U	0.0500 U	0.0200 U	0.0200 U	0.0200 U	0.0200 U	0.0200 U	0.0200 U	**5.60**	**0.0800**	**0.0780**	0.0750 U
	24-Mar-04	Primary	0.500 U	1.00 U	**5.49**	**5.50**	0.500 U	0.500 U	**6.30**	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	**46.0**	0.500 U	1.00 U	1.50 U
	24-Mar-04	Dup	0.500 U	1.00 U	**5.17**	**5.20**	0.500 U	0.500 U	**6.00**	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	**48.0**	0.500 U	1.00 U	1.50 U
	20-Apr-04	Primary	0.200 U	0.500 U	**41.0**	**41.0**	0.200 U	0.200 U	**4.48**	0.200 U	0.200 U	0.200 U	0.200 U	0.200 U	0.200 U	**6.20**	**0.300**	0.500 U	0.750 U
	18-May-04	Primary	0.500 U	1.00 U	**37.6**	**38.0**	0.500 U	0.500 U	**3.90**	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	**7.20**	0.500 U	1.00 U	1.50 U
	29-Sep-04	Primary	0.500 U	1.00 U	**39.6**	**40.0**	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	**3.10**	0.500 U	1.00 U	1.50 U
	29-Sep-04	Dup	0.500 U	1.00 U	**41.0**	**41.0**	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	**3.80**	0.500 U	1.00 U	1.50 U
16PM06	27-Jun-03	Primary	1.00 U	2.00 U	**15.9**	**16.0**	1.00 U	1.00 U	**2.00**	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	**140**	1.00 U	2.00 U	3.00 U
	23-Mar-04	Primary	0.200 U	0.500 U	**9.33**	**9.30**	0.200 U	0.200 U	**5.84**	0.200 U	0.200 U	0.200 U	0.200 U	0.200 U	0.200 U	**58.0**	**0.300**	0.500 U	0.750 U
	20-Apr-04	Primary	0.0500 U	0.100 U	**68.7**	**69.0**	0.0500 U	0.0500 U	**8.40**	0.0500 U	0.0500 U	0.0500 U	0.0500 U	**0.0700**	0.0500 U	**14.0**	**0.330**	**0.430**	0.150 U
	19-May-04	Primary	0.500 U	1.00 U	**41.3**	**41.0**	0.500 U	0.500 U	**1.10**	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	**27.0**	0.500 U	1.00 U	1.50 U
	28-Sep-04	Primary	0.100 U	0.200 U	**30.2**	**30.0**	0.100 U	0.100 U	**0.430**	0.100 U	0.100 U	0.100 U	0.100 U	**0.200**	0.100 U	**102**	**0.600**	**0.680**	0.300 U
	28-Sep-04	Dup	0.100 U	0.200 U	**32.0**	**32.0**	0.100 U	0.100 U	0.200 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	**88.0**	**0.500**	**0.710**	0.300 U

TABLE F-7: RESULTS OF VOC ANALYSIS.
Site 16 Landfill, LHAAP, Karnack, Texas

			Concentration (mg/L)																			
Location	Date Sampled	Type	1,1,1-Trichloroethane	1,1,2,2-Tetrachloroethane	1,1,2-Trichloroethane	1,1-Dichloroethane	1,1-Dichloroethene	1,2-Dichloroethane	1,2-Dichloropropane	2-Butanone (MEK)	2-Butanone (MEK), TCLP	2-Hexanone	4-Methyl-2-pentanone	Acetone	Benzene	Bromodichloro-methane	Bromoform	Bromomethane	Carbon disulfide	Carbon-tetrachloride	Chlorobenzene	Chloroethane
16PM07-D	27-Jun-03	Primary	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U		2.00 U	2.00 U	2.00 U	2.00 U	1.00 U	1.00 U	1.00 U	2.00 U	1.00 U	1.00 U	1.00 U	2.00 U
	23-Mar-04	Primary	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	2.50 U		2.50 U	2.50 U	2.50 U	1.00 U	1.00 U	1.00 U	2.50 U	1.00 U	1.00 U	1.00 U	2.50 U
	20-Apr-04	Primary	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	2.00 U		2.00 U	2.00 U	2.00 U	1.00 U	1.00 U	1.00 U	2.00 U	1.00 U	1.00 U	1.00 U	2.00 U
	19-May-04	Primary	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	1.00 U		1.00 U	1.00 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U
	28-Sep-04	Primary	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	1.00 U		1.00 U	1.00 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U
16PM07-S	27-Jun-03	Primary	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U		1.00 U	1.00 U	1.00 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U
	23-Mar-04	Primary	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	2.50 U		2.50 U	2.50 U	2.50 U	1.00 U	1.00 U	1.00 U	2.50 U	1.00 U	1.00 U	1.00 U	2.50 U
	20-Apr-04	Primary	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	2.00 U		2.00 U	2.00 U	2.00 U	1.00 U	1.00 U	1.00 U	2.00 U	1.00 U	1.00 U	1.00 U	2.00 U
	19-May-04	Primary	0.00500 U	0.00500 U	**0.0310**	**0.0100**	**0.300**	**0.175**	0.00500 U	0.0100 U		0.0100 U	**0.0160**	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U
	28-Sep-04	Primary	0.200 U	0.200 U	0.200 U	0.200 U	0.200 U	0.200 U	0.200 U	0.500 U		0.500 U	0.500 U	0.500 U	0.200 U	0.200 U	0.200 U	0.500 U	0.200 U	0.200 U	0.200 U	0.500 U
16PM08	27-Jun-03	Primary	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U		2.50 U	2.50 U	2.50 U	2.50 U	1.00 U	1.00 U	1.00 U	2.50 U	1.00 U	1.00 U	1.00 U	2.50 U
	27-Jun-03	Dup	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U		2.50 U	2.50 U	2.50 U	2.50 U	1.00 U	1.00 U	1.00 U	2.50 U	1.00 U	1.00 U	1.00 U	2.50 U
	23-Mar-04	Primary	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	5.00 U		5.00 U	5.00 U	5.00 U	2.00 U	2.00 U	2.00 U	5.00 U	2.00 U	2.00 U	2.00 U	5.00 U
	21-Apr-04	Primary	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	2.00 U		2.00 U	2.00 U	2.00 U	1.00 U	1.00 U	1.00 U	2.00 U	1.00 U	1.00 U	1.00 U	2.00 U
	19-May-04	Primary	0.500 U	0.500 U	0.500 U	0.500 U	**0.500**	0.500 U	0.500 U	1.00 U		1.00 U	1.00 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U
	28-Sep-04	Primary	0.200 U	0.200 U	0.200 U	0.200 U	**0.300**	0.200 U	0.200 U	0.500 U		0.500 U	0.500 U	0.500 U	0.200 U	0.200 U	0.200 U	0.500 U	0.200 U	0.200 U	0.200 U	0.500 U
16PM09	26-Jun-03	Primary	0.0200 U	0.0200 U	0.0200 U	0.0200 U	**0.0300**	0.0200 U	0.0200 U		0.0500 U	0.0500 U	0.0500 U	0.0500 U	0.0200 U	0.0200 U	0.0200 U	0.0500 U	0.0200 U	0.0200 U	0.0200 U	0.0500 U
	24-Mar-04	Primary	0.200 U	0.200 U	0.200 U	0.200 U	0.200 U	0.200 U	0.200 U	0.500 U		0.500 U	0.500 U	0.500 U	0.200 U	0.200 U	0.200 U	0.500 U	0.200 U	0.200 U	0.200 U	0.500 U
	20-Apr-04	Primary	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	2.00 U		2.00 U	2.00 U	2.00 U	1.00 U	1.00 U	1.00 U	2.00 U	1.00 U	1.00 U	1.00 U	2.00 U
	18-May-04	Primary	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.200 U		0.200 U	0.200 U	0.200 U	0.100 U	0.100 U	0.100 U	0.200 U	0.100 U	0.100 U	0.100 U	0.200 U
	29-Sep-04	Primary	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.200 U		0.200 U	0.200 U	0.200 U	0.100 U	0.100 U	0.100 U	0.200 U	0.100 U	0.100 U	0.100 U	0.200 U
16PM10-D	27-Jun-03	Primary	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U		2.00 U	2.00 U	2.00 U	2.00 U	1.00 U	1.00 U	1.00 U	2.00 U	1.00 U	1.00 U	1.00 U	2.00 U
	24-Mar-04	Primary	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	10.0 U		10.0 U	10.0 U	10.0 U	5.00 U	5.00 U	5.00 U	10.0 U	5.00 U	5.00 U	5.00 U	10.0 U
	21-Apr-04	Primary	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	2.00 U		2.00 U	2.00 U	2.00 U	1.00 U	1.00 U	1.00 U	2.00 U	1.00 U	1.00 U	1.00 U	2.00 U
	19-May-04	Primary	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	1.00 U		1.00 U	1.00 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U
	28-Sep-04	Primary	0.200 U	0.200 U	0.200 U	0.200 U	0.200 U	0.200 U	0.200 U	0.500 U		0.500 U	0.500 U	0.500 U	0.200 U	0.200 U	0.200 U	0.500 U	0.200 U	0.200 U	0.200 U	0.500 U
16PM10-S	27-Jun-03	Primary	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U		1.00 U	1.00 U	1.00 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U
	24-Mar-04	Primary	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	1.00 U		1.00 U	1.00 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U
	21-Apr-04	Primary	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	2.00 U		2.00 U	2.00 U	2.00 U	1.00 U	1.00 U	1.00 U	2.00 U	1.00 U	1.00 U	1.00 U	2.00 U
	19-May-04	Primary	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	1.00 U		1.00 U	1.00 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U
	28-Sep-04	Primary	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	1.00 U		1.00 U	1.00 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U
16PM11	27-Jun-03	Primary	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U		2.00 U	2.00 U	2.00 U	2.00 U	1.00 U	1.00 U	1.00 U	2.00 U	1.00 U	1.00 U	1.00 U	2.00 U
	23-Mar-04	Primary	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	2.50 U		2.50 U	2.50 U	2.50 U	1.00 U	1.00 U	1.00 U	2.50 U	1.00 U	1.00 U	1.00 U	2.50 U
	21-Apr-04	Primary	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	2.00 U		2.00 U	2.00 U	2.00 U	1.00 U	1.00 U	1.00 U	2.00 U	1.00 U	1.00 U	1.00 U	2.00 U
	20-May-04	Primary	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	1.00 U		1.00 U	1.00 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U
	28-Sep-04	Primary	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	1.00 U		1.00 U	1.00 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U
16PM12	26-Jun-03	Primary	0.0500 U	0.0500 U	0.0500 U	0.0500 U	0.0500 U	0.0500 U	0.0500 U		0.100 U	0.100 U	0.100 U	0.100 U	0.0500 U	0.0500 U	0.0500 U	0.100 U	0.0500 U	0.0500 U	0.0500 U	0.100 U
	24-Mar-04	Primary	0.0500 U	0.0500 U	0.0500 U	0.0500 U	0.0500 U	0.0500 U	0.0500 U	0.100 U		0.100 U	0.100 U	0.100 U	0.0500 U	0.0500 U	0.0500 U	0.100 U	0.0500 U	0.0500 U	0.0500 U	0.100 U
	20-Apr-04	Primary	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.200 U		0.200 U	0.200 U	0.200 U	0.100 U	0.100 U	0.100 U	0.200 U	0.100 U	0.100 U	0.100 U	0.200 U
	18-May-04	Primary	0.00500 U	0.00500 U	0.00500 U	0.00500 U	**0.0460**	0.00500 U	0.00500 U	0.0100 U		0.0100 U	0.0100 U	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U
	29-Sep-04	Primary	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.200 U		0.200 U	0.200 U	0.200 U	0.100 U	0.100 U	0.100 U	0.200 U	0.100 U	0.100 U	0.100 U	0.200 U
16PM13-D	27-Jun-03	Primary	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U		2.00 U	2.00 U	2.00 U	2.00 U	1.00 U	1.00 U	1.00 U	2.00 U	1.00 U	1.00 U	1.00 U	2.00 U
	23-Mar-04	Primary	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	2.50 U		2.50 U	2.50 U	2.50 U	1.00 U	1.00 U	1.00 U	2.50 U	1.00 U	1.00 U	1.00 U	2.50 U
	21-Apr-04	Primary	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	2.00 U		2.00 U	2.00 U	2.00 U	1.00 U	1.00 U	1.00 U	2.00 U	1.00 U	1.00 U	1.00 U	2.00 U
	19-May-04	Primary	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	1.00 U		1.00 U	1.00 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U
	28-Sep-04	Primary	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	1.00 U		1.00 U	1.00 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U
16PM13-S	27-Jun-03	Primary	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U		2.00 U	2.00 U	2.00 U	2.00 U	1.00 U	1.00 U	1.00 U	2.00 U	1.00 U	1.00 U	1.00 U	2.00 U
	23-Mar-04	Primary	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	2.50 U		2.50 U	2.50 U	2.50 U	1.00 U	1.00 U	1.00 U	2.50 U	1.00 U	1.00 U	1.00 U	2.50 U
	21-Apr-04	Primary	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	2.00 U		2.00 U	2.00 U	2.00 U	1.00 U	1.00 U	1.00 U	2.00 U	1.00 U	1.00 U	1.00 U	2.00 U
	19-May-04	Primary	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	1.00 U		1.00 U	1.00 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U
	28-Sep-04	Primary	0.200 U	0.200 U	0.200 U	0.200 U	0.200 U	0.200 U	0.200 U	0.500 U		0.500 U	0.500 U	0.500 U	0.200 U	0.200 U	0.200 U	0.500 U	0.200 U	0.200 U	0.200 U	0.500 U
16PM14	27-Jun-03	Primary	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U		1.00 U	1.00 U	1.00 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U
	23-Mar-04	Primary	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	2.50 U		2.50 U	2.50 U	2.50 U	1.00 U	1.00 U	1.00 U	2.50 U	1.00 U	1.00 U	1.00 U	2.50 U
	23-Mar-04	Dup	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	2.50 U		2.50 U	2.50 U	2.50 U	1.00 U	1.00 U	1.00 U	2.50 U	1.00 U	1.00 U	1.00 U	2.50 U
	21-Apr-04	Primary	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	2.00 U		2.00 U	2.00 U	2.00 U	1.00 U	1.00 U	1.00 U	2.00 U	1.00 U	1.00 U	1.00 U	2.00 U
	20-May-04	Primary	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	1.00 U		1.00 U	1.00 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U
	28-Sep-04	Primary	0.200 U	0.200 U	0.200 U	0.200 U	0.200 U	0.200 U	0.200 U	0.500 U		0.500 U	0.500 U	0.500 U	0.200 U	0.200 U	0.200 U	0.500 U	0.200 U	0.200 U	0.200 U	0.500 U
16WW16	30-Jun-03	Primary	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U		1.00 U	1.00 U	1.00 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	1.00 U
TRIP BLANK	27-Mar-03	Primary	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U		0.0100 U	0.0100 U	0.0100 U	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U
	26-Jun-03	Primary	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U		0.0100 U	0.0100 U	0.0100 U	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U
	27-Jun-03	Primary	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U		0.0100 U	0.0100 U	0.0100 U	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U
	30-Jun-03	Primary	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U		0.0100 U	0.0100 U	0.0100 U	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U
	23-Mar-04	Primary	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U		0.0100 U	0.0100 U	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U
	24-Mar-04	Primary	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U		0.0100 U	0.0100 U	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U
	20-Apr-04	Primary	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U		0.0100 U	0.0100 U	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U
	21-Apr-04	Primary	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U		0.0100 U	0.0100 U	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U
	18-May-04	Primary	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U		0.0100 U	0.0100 U	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U
	18-May-04	Dup	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U		0.0100 U	0.0100 U	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U

TABLE F-7: RESULTS OF VOC ANALYSIS.
Site 16 Landfill, LHAAP, Karnack, Texas

			Concentration (mg/L)																
Location	Date Sampled	Type	Chloroform	Chloromethane	cis/trans1,2-Dichloroethene	cis-1,2-Dichloroethene	cis-1,3-Dichloropropene	Dibromo-chloromethane	Dichloromethane (Methylene chloride)	Ethyl benzene	Styrene	Tetrachloroethene	Toluene	trans-1,2-Dichloroethene	trans-1,3-Dichloropropene	Trichloroethene	Trichloro-trifluoroethane	Vinyl chloride	Xylenes (unspecified)
16PM07-D	27-Jun-03	Primary	1.00 U	2.00 U	**75.5**	**70.0**	1.00 U	1.00 U	2.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	**70.0**	1.00 U	**2.10**	3.00 U
	23-Mar-04	Primary	1.00 U	2.50 U	**105**	**110**	1.00 U	1.00 U	2.50 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	**130**	1.00 U	**4.30**	3.80 U
	20-Apr-04	Primary	1.00 U	2.00 U	**82.3**	**80.0**	1.00 U	1.00 U	2.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	**140**	1.00 U	**4.60**	3.00 U
	19-May-04	Primary	0.500 U	1.00 U	**85.3**	**90.0**	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	**130**	0.500 U	**2.50**	1.50 U
	28-Sep-04	Primary	0.500 U	1.00 U	**63.5**	**60.0**	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	**140**	**0.500**	**2.40**	1.50 U
16PM07-S	27-Jun-03	Primary	0.500 U	1.00 U	**37.3**	**37.0**	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	**60.0**	0.500 U	1.00 U	1.50 U
	23-Mar-04	Primary	1.00 U	2.50 U	**74.5**	**70.0**	1.00 U	1.00 U	2.50 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	**140**	1.00 U	2.50 U	3.80 U
	20-Apr-04	Primary	1.00 U	2.00 U	**57.8**	**60.0**	1.00 U	1.00 U	2.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	**130**	1.00 U	**2.30**	3.00 U
	19-May-04	Primary	**0.0330**	0.0100 U	**67.2**	**67.0**	0.00500 U	0.00500 U	**0.570**	0.00500 U	0.00500 U	0.00500 U	**0.00900**	**0.281**	0.00500 U	**120**	**0.500**	**1.49**	**0.0170**
	28-Sep-04	Primary	0.200 U	0.500 U	**70.5**	**70.0**	0.200 U	0.200 U	0.500 U	0.200 U	0.200 U	0.200 U	0.200 U	0.200 U	0.200 U	**154**	**0.300**	**2.57**	0.750 U
16PM08	27-Jun-03	Primary	1.00 U	2.50 U	**170**	**170**	1.00 U	1.00 U	2.50 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	**20.0**	1.00 U	**6.30**	3.80 U
	27-Jun-03	Dup	1.00 U	2.50 U	**158**	**160**	1.00 U	1.00 U	2.50 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	**20.0**	1.00 U	**6.40**	3.80 U
	23-Mar-04	Primary	2.00 U	5.00 U	**202**	**202**	2.00 U	2.00 U	5.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	**30.0**	2.00 U	**10.3**	7.50 U
	21-Apr-04	Primary	1.00 U	2.00 U	**159**	**160**	1.00 U	1.00 U	2.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	**24.0**	1.00 U	**10.4**	3.00 U
	19-May-04	Primary	0.500 U	1.00 U	**157**	**160**	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	**20.0**	0.500 U	**5.50**	1.50 U
	28-Sep-04	Primary	0.200 U	0.500 U	**131**	**131**	0.200 U	0.200 U	0.500 U	0.200 U	0.200 U	0.200 U	0.200 U	**0.400**	0.200 U	**29.0**	0.200 U	**6.77**	0.750 U
16PM09	26-Jun-03	Primary	0.0200 U	0.0500 U	**0.768**	**0.770**	0.0200 U	0.0200 U	0.0500 U	0.0200 U	0.0200 U	0.0200 U	0.0200 U	0.0200 U	0.0200 U	**3.30**	**0.160**	**0.0630**	0.0750 U
	24-Mar-04	Primary	0.200 U	0.500 U	**2.68**	**2.70**	0.200 U	0.200 U	**1.98**	0.200 U	0.200 U	0.200 U	0.200 U	0.200 U	0.200 U	**18.0**	**0.300**	0.500 U	0.750 U
	20-Apr-04	Primary	1.00 U	2.00 U	**2.88**	**3.00**	1.00 U	1.00 U	**2.90**	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	**25.0**	1.00 U	2.00 U	3.00 U
	18-May-04	Primary	0.100 U	0.200 U	**6.26**	**6.30**	0.500 U	0.100 U	**1.29**	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	**12.1**	**0.300**	0.200 U	0.300 U
	29-Sep-04	Primary	0.100 U	0.200 U	**6.16**	**6.10**	0.100 U	0.100 U	0.200 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	**6.40**	**0.200**	0.200 U	0.300 U
16PM10-D	27-Jun-03	Primary	1.00 U	2.00 U	**15.3**	**15.0**	1.00 U	1.00 U	**31.0**	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	**130**	**1.00**	2.00 U	3.00 U
	24-Mar-04	Primary	5.00 U	10.0 U	**27.8**	**28.0**	5.00 U	5.00 U	10.0 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	5.00 U	**300**	5.00 U	10.0 U	15.0 U
	21-Apr-04	Primary	1.00 U	2.00 U	**37.4**	**37.0**	1.00 U	1.00 U	2.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	**260**	**2.00**	2.00 U	3.00 U
	19-May-04	Primary	0.500 U	1.00 U	**34.6**	**30.0**	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	**170**	**1.50**	**1.40**	1.50 U
	28-Sep-04	Primary	0.200 U	0.500 U	**46.1**	**50.0**	0.200 U	0.200 U	**0.640**	0.200 U	0.200 U	0.200 U	0.200 U	0.200 U	0.200 U	**160**	**0.800**	**1.60**	0.750 U
16PM10-S	27-Jun-03	Primary	0.500 U	1.00 U	**3.66**	**3.70**	0.500 U	0.500 U	**8.20**	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	**48.0**	0.500 U	1.00 U	1.50 U
	24-Mar-04	Primary	0.500 U	1.00 U	**13.3**	**13.3**	0.500 U	0.500 U	**4.30**	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	**55.0**	0.500 U	1.00 U	1.50 U
	21-Apr-04	Primary	1.00 U	2.00 U	**17.2**	**17.0**	1.00 U	1.00 U	**5.20**	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	**64.0**	1.00 U	2.00 U	3.00 U
	19-May-04	Primary	0.500 U	1.00 U	**32.2**	**32.0**	0.500 U	0.500 U	**2.50**	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	**52.0**	**0.700**	1.00 U	1.50 U
	28-Sep-04	Primary	0.500 U	1.00 U	**18.0**	**18.0**	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	**120**	**0.700**	1.00 U	1.50 U
16PM11	27-Jun-03	Primary	1.00 U	2.00 U	**103**	**100**	1.00 U	1.00 U	2.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	**50.0**	1.00 U	**2.90**	3.00 U
	23-Mar-04	Primary	1.00 U	2.50 U	**164**	**160**	1.00 U	1.00 U	2.50 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	**80.0**	1.00 U	**4.50**	3.80 U
	21-Apr-04	Primary	1.00 U	2.00 U	**89.0**	**89.0**	1.00 U	1.00 U	2.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	**39.0**	1.00 U	**4.40**	3.00 U
	20-May-04	Primary	0.500 U	1.00 U	**115**	**115**	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	**41.0**	0.500 U	**2.20**	1.50 U
	28-Sep-04	Primary	0.500 U	1.00 U	**72.1**	**72.0**	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	**49.0**	0.500 U	**3.40**	1.50 U
16PM12	26-Jun-03	Primary	0.0500 U	0.100 U	**0.413**	**0.410**	0.0500 U	0.0500 U	0.100 U	0.0500 U	0.0500 U	0.0500 U	0.0500 U	0.0500 U	0.0500 U	**5.60**	**0.230**	0.100 U	0.150 U
	24-Mar-04	Primary	0.0500 U	0.100 U	**0.688**	**0.690**	0.0500 U	0.0500 U	0.100 U	0.0500 U	0.0500 U	0.0500 U	0.0500 U	0.0500 U	0.0500 U	**7.50**	**0.300**	0.100 U	0.150 U
	20-Apr-04	Primary	0.100 U	0.200 U	**0.608**	**0.600**	0.100 U	0.100 U	0.200 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	**10.0**	**0.200**	0.200 U	0.300 U
	18-May-04	Primary	0.00500 U	0.0100 U	**1.01**	**1.01**	0.00500 U	0.00500 U	**0.290**	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	**9.00**	**0.280**	**0.0820**	0.0150 U
	29-Sep-04	Primary	0.100 U	0.200 U	**0.921**	**0.900**	0.100 U	0.100 U	0.200 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	**6.90**	**0.200**	0.200 U	0.300 U
16PM13-D	27-Jun-03	Primary	1.00 U	2.00 U	**26.2**	**26.0**	1.00 U	1.00 U	2.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	**130**	**1.00**	2.00 U	3.00 U
	23-Mar-04	Primary	1.00 U	2.50 U	**45.7**	**46.0**	1.00 U	1.00 U	2.50 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	**150**	1.00 U	2.50 U	3.80 U
	21-Apr-04	Primary	1.00 U	2.00 U	**36.3**	**36.0**	1.00 U	1.00 U	2.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	**130**	1.00 U	2.00 U	3.00 U
	19-May-04	Primary	0.500 U	1.00 U	**104**	**100**	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	**120**	**0.500**	**1.20**	1.50 U
	28-Sep-04	Primary	0.500 U	1.00 U	**30.0**	**30.0**	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	**123**	**0.600**	**1.30**	1.50 U
16PM13-S	27-Jun-03	Primary	1.00 U	2.00 U	**75.5**	**80.0**	1.00 U	1.00 U	2.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	**130**	1.00 U	2.00 U	3.00 U
	23-Mar-04	Primary	1.00 U	2.50 U	**124**	**120**	1.00 U	1.00 U	2.50 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	**180**	1.00 U	**4.30**	3.80 U
	21-Apr-04	Primary	1.00 U	2.00 U	**68.3**	**70.0**	1.00 U	1.00 U	2.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	**170**	1.00 U	**3.00**	3.00 U
	19-May-04	Primary	0.500 U	1.00 U	**61.0**	**60.0**	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	**130**	**0.600**	**1.60**	1.50 U
	28-Sep-04	Primary	0.200 U	0.500 U	**62.1**	**62.0**	0.200 U	0.200 U	**0.500**	0.200 U	0.200 U	0.200 U	0.200 U	0.200 U	0.200 U	**151**	**0.600**	**2.03**	0.750 U
16PM14	27-Jun-03	Primary	0.500 U	1.00 U	**82.7**	**83.0**	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	**53.0**	0.500 U	**2.20**	1.50 U
	23-Mar-04	Primary	1.00 U	2.50 U	**72.1**	**70.0**	1.00 U	1.00 U	2.50 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	**47.0**	1.00 U	2.50 U	3.80 U
	23-Mar-04	Dup	1.00 U	2.50 U	**81.0**	**81.0**	1.00 U	1.00 U	2.50 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	**51.0**	1.00 U	2.50 U	3.80 U
	21-Apr-04	Primary	1.00 U	2.00 U	**53.9**	**54.0**	1.00 U	1.00 U	2.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	**42.0**	1.00 U	**2.30**	3.00 U
	20-May-04	Primary	0.500 U	1.00 U	**41.5**	**42.0**	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	**35.0**	0.500 U	**1.20**	1.50 U
	28-Sep-04	Primary	0.200 U	0.500 U	**36.5**	**36.0**	0.200 U	0.200 U	0.500 U	0.200 U	0.200 U	0.200 U	0.200 U	0.200 U	0.200 U	**56.0**	0.200 U	**1.71**	0.750 U
16WW16	30-Jun-03	Primary	0.500 U	1.00 U	**53.9**	**54.0**	0.500 U	0.500 U	1.00 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	**19.8**	0.500 U	**2.10**	1.50 U
TRIP BLANK	27-Mar-03	Primary	0.00500 U	0.0100 U	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U	0.0150 U
	26-Jun-03	Primary	0.00500 U	0.0100 U	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U	0.0150 U
	27-Jun-03	Primary	0.00500 U	0.0100 U	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U	0.0150 U
	30-Jun-03	Primary	0.00500 U	0.0100 U	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U	0.0150 U
	23-Mar-04	Primary	0.00500 U	0.0100 U	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U	0.0150 U
	24-Mar-04	Primary	0.00500 U	0.0100 U	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U	0.0150 U
	20-Apr-04	Primary	0.00500 U	0.0100 U	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U	0.0150 U
	21-Apr-04	Primary	0.00500 U	0.0100 U	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U	0.0150 U
	18-May-04	Primary	0.00500 U	0.0100 U	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U	0.0150 U
	18-May-04	Dup	0.00500 U	0.0100 U	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.00500 U	0.0100 U	0.0150 U

TABLE F-8: RESULTS OF DISSOLVED HYDROCARBON GASES ANALYSIS.
Site 16 Landfill, LHAAP, Karnack, Texas

			Concentration (mg/L)		
Location	Date Sampled	Type	Ethane	Ethene	Methane
16EW09	27-Mar-03	Primary	3.00 U	3.00 U	2.00 U
	24-Mar-04	Primary	3.00 U	3.00 U	0.650 U
	21-Apr-04	Primary	3.00 U	3.00 U	0.650 U
	21-Apr-04	Dup	3.00 U	3.00 U	0.650 U
	20-May-04	Primary	3.00 U	3.00 U	0.650 U
	29-Sep-04	Primary	3.00 U	3.00 U	0.650 U
16EW10	27-Mar-03	Primary	3.00 U	3.00 U	2.00 U
	23-Mar-04	Primary	3.00 U	3.00 U	0.650 U
	21-Apr-04	Primary	3.00 U	3.00 U	0.650 U
	21-Apr-04	Dup	3.00 U	3.00 U	0.650 U
	20-May-04	Primary	3.00 U	3.00 U	0.650 U
	20-May-04	Dup	3.00 U	3.00 U	0.650 U
	29-Sep-04	Primary	3.00 U	3.00 U	0.650 U
16EW11	27-Mar-03	Primary	3.00 U	3.00 U	2.00 U
16EW12	30-Jun-03	Primary	3.00 U	3.00 U	2.00 U
16EW12B	24-Mar-04	Primary	3.00 U	3.00 U	0.650 U
	21-Apr-04	Primary	3.00 U	3.00 U	0.650 U
	20-May-04	Primary	3.00 U	3.00 U	0.650 U
	29-Sep-04	Primary	3.00 U	3.00 U	0.650 U
16EW13	26-Jun-03	Primary	3.00 U	3.00 U	2.00 U
16EW14	26-Jun-03	Primary	3.00 U	3.00 U	2.00 U
16EW14B	24-Mar-04	Primary	3.00 U	3.00 U	0.650 U
	21-Apr-04	Primary	3.00 U	3.00 U	0.650 U
	20-May-04	Primary	3.00 U	3.00 U	0.650 U
	29-Sep-04	Primary	3.00 U	3.00 U	**7.74**
16EW15	26-Jun-03	Primary	3.00 U	3.00 U	2.00 U
	26-Jun-03	Dup	3.00 U	3.00 U	2.00 U
16PM01	26-Jun-03	Primary	3.00 U	3.00 U	2.00 U
	23-Mar-04	Primary	3.00 U	3.00 U	0.650 U
	20-Apr-04	Primary	3.00 U	3.00 U	0.650 U
	18-May-04	Primary	3.00 U	3.00 U	**0.830**
	28-Sep-04	Primary	3.00 U	3.00 U	**2.18**
16PM02	26-Jun-03	Primary	3.00 U	3.00 U	2.00 U
	23-Mar-04	Primary	3.00 U	3.00 U	0.650 U
	20-Apr-04	Primary	3.00 U	3.00 U	0.650 U
	18-May-04	Primary	3.00 U	3.00 U	0.650 U
	28-Sep-04	Primary	3.00 U	3.00 U	**5.19**
16PM03	30-Jun-03	Primary	3.00 U	3.00 U	2.00 U
	23-Mar-04	Primary	3.00 U	3.00 U	0.650 U
	20-Apr-04	Primary	3.00 U	3.00 U	0.650 U
	18-May-04	Primary	3.00 U	3.00 U	0.650 U
	28-Sep-04	Primary	3.00 U	3.00 U	0.650 U

TABLE F-8: RESULTS OF DISSOLVED HYDROCARBON GASES ANALYSIS.
Site 16 Landfill, LHAAP, Karnack, Texas

			Concentration (mg/L)		
Location	Date Sampled	Type	Ethane	Ethene	Methane
16PM04	27-Jun-03	Primary	3.00 U	3.00 U	2.00 U
	23-Mar-04	Primary	3.00 U	3.00 U	0.650 U
	20-Apr-04	Primary	3.00 U	3.00 U	0.650 U
	18-May-04	Primary	3.00 U	3.00 U	0.650 U
	18-May-04	Dup	3.00 U	3.00 U	0.650 U
	28-Sep-04	Primary	3.00 U	3.00 U	0.650 U
16PM05	26-Jun-03	Primary	3.00 U	3.00 U	2.00 U
	24-Mar-04	Primary	3.00 U	3.00 U	0.650 U
	24-Mar-04	Dup	3.00 U	3.00 U	0.650 U
	20-Apr-04	Primary	3.00 U	3.00 U	0.650 U
	18-May-04	Primary	3.00 U	3.00 U	0.650 U
	29-Sep-04	Primary	3.00 U	3.00 U	0.650 U
	29-Sep-04	Dup	3.00 U	3.00 U	0.650 U
16PM06	27-Jun-03	Primary	3.00 U	3.00 U	2.00 U
	23-Mar-04	Primary	3.00 U	3.00 U	0.650 U
	20-Apr-04	Primary	3.00 U	3.00 U	0.650 U
	19-May-04	Primary	3.00 U	3.00 U	0.650 U
	28-Sep-04	Primary	3.00 U	3.00 U	0.650 U
	28-Sep-04	Dup	3.00 U	3.00 U	0.650 U
16PM07-D	27-Jun-03	Primary	3.00 U	3.00 U	2.00 U
	23-Mar-04	Primary	3.00 U	3.00 U	0.650 U
	20-Apr-04	Primary	3.00 U	3.00 U	0.650 U
	19-May-04	Primary	3.00 U	3.00 U	0.650 U
	28-Sep-04	Primary	3.00 U	3.00 U	0.650 U
16PM07-S	27-Jun-03	Primary	3.00 U	3.00 U	2.00 U
	23-Mar-04	Primary	3.00 U	3.00 U	0.650 U
	20-Apr-04	Primary	3.00 U	3.00 U	0.650 U
	19-May-04	Primary	3.00 U	3.00 U	0.650 U
	28-Sep-04	Primary	3.00 U	3.00 U	0.650 U
16PM08	27-Jun-03	Primary	3.00 U	3.00 U	2.00 U
	27-Jun-03	Dup	3.00 U	3.00 U	2.00 U
	23-Mar-04	Primary	3.00 U	3.00 U	0.650 U
	21-Apr-04	Primary	3.00 U	3.00 U	0.650 U
	19-May-04	Primary	3.00 U	3.00 U	0.650 U
	28-Sep-04	Primary	3.00 U	3.00 U	0.650 U
16PM09	26-Jun-03	Primary	3.00 U	3.00 U	2.00 U
	24-Mar-04	Primary	3.00 U	3.00 U	0.650 U
	20-Apr-04	Primary	3.00 U	3.00 U	0.650 U
	18-May-04	Primary	3.00 U	3.00 U	0.650 U
	29-Sep-04	Primary	3.00 U	3.00 U	**3.36**
16PM10-D	27-Jun-03	Primary	3.00 U	3.00 U	2.00 U
	24-Mar-04	Primary	3.00 U	3.00 U	0.650 U
	21-Apr-04	Primary	3.00 U	3.00 U	0.650 U
	19-May-04	Primary	3.00 U	3.00 U	0.650 U
	28-Sep-04	Primary	3.00 U	3.00 U	0.650 U

TABLE F-8: RESULTS OF DISSOLVED HYDROCARBON GASES ANALYSIS.
Site 16 Landfill, LHAAP, Karnack, Texas

			Concentration (mg/L)		
Location	Date Sampled	Type	Ethane	Ethene	Methane
16PM10-S	27-Jun-03	Primary	3.00 U	3.00 U	2.00 U
	24-Mar-04	Primary	3.00 U	3.00 U	0.650 U
	21-Apr-04	Primary	3.00 U	3.00 U	0.650 U
	19-May-04	Primary	3.00 U	3.00 U	0.650 U
	28-Sep-04	Primary	3.00 U	3.00 U	0.650 U
16PM11	27-Jun-03	Primary	3.00 U	3.00 U	2.00 U
	23-Mar-04	Primary	3.00 U	3.00 U	0.650 U
	21-Apr-04	Primary	3.00 U	3.00 U	0.650 U
	20-May-04	Primary	3.00 U	3.00 U	0.650 U
	28-Sep-04	Primary	3.00 U	3.00 U	0.650 U
16PM12	26-Jun-03	Primary	3.00 U	3.00 U	2.00 U
	24-Mar-04	Primary	3.00 U	3.00 U	0.650 U
	20-Apr-04	Primary	3.00 U	3.00 U	0.650 U
	18-May-04	Primary	3.00 U	3.00 U	0.650 U
	29-Sep-04	Primary	3.00 U	3.00 U	0.650 U
16PM13-D	27-Jun-03	Primary	3.00 U	3.00 U	2.00 U
	23-Mar-04	Primary	3.00 U	3.00 U	0.650 U
	21-Apr-04	Primary	3.00 U	3.00 U	0.650 U
	19-May-04	Primary	3.00 U	3.00 U	0.650 U
	28-Sep-04	Primary	3.00 U	3.00 U	0.650 U
16PM13-S	27-Jun-03	Primary	3.00 U	3.00 U	2.00 U
	23-Mar-04	Primary	3.00 U	3.00 U	0.650 U
	21-Apr-04	Primary	3.00 U	3.00 U	0.650 U
	19-May-04	Primary	3.00 U	3.00 U	0.650 U
	28-Sep-04	Primary	3.00 U	3.00 U	0.650 U
16PM14	27-Jun-03	Primary	3.00 U	3.00 U	2.00 U
	23-Mar-04	Primary	3.00 U	3.00 U	0.650 U
	23-Mar-04	Dup	3.00 U	3.00 U	0.650 U
	21-Apr-04	Primary	3.00 U	3.00 U	0.650 U
	20-May-04	Primary	3.00 U	3.00 U	0.650 U
	28-Sep-04	Primary	3.00 U	3.00 U	0.650 U
16WW16	30-Jun-03	Primary	3.00 U	3.00 U	2.00 U

APPENDIX F
STATISTICAL ANALYSIS OF ORP AND PERCHLOTATE DATA

1. INTRODUCTION

This section presents the results of statistical analysis of key monitoring parameters (ORP and perchlorate concentrations) to assess the changes in these parameters resulting from the addition of electron donor to the subsurface. Analysis of ORP data is presented in Section 2 and analysis of perchlorate data is presented in Section 3.

2. EVALUATION OF ORP DATA

A statistical evaluation of ORP data collected from five key monitoring wells along the alignment of the biobarrier was conducted. The wells selected for this evaluation consisted of:

1. 16PM05 – closest to the alignment of the biobarrier in Transect 1;
2. 16EW14B – along the biobarrier between Transect 1 and Transect 2;
3. 16PM06 - closest to the alignment of the biobarrier in Transect 2;
4. 16PM04 - closest to the alignment of the biobarrier in Transect 3; and
5. 16EW12B - closest to the alignment of the biobarrier in Transect 4.

Wells along the alignment of the biobarrier were selected as they are expected to show the most significant change in ORP and are located along an alignment across which groundwater from upgradient of the biobarrier will pass.

Data from four different time periods were evaluated for the statistical analysis to represent four different phases of the demonstration test. The specific periods of time were:

1. Baseline data before amendment with electron donor;
2. 2 to 6 weeks after the 1st amendment with electron donor;
3. 4 to 20 after the 2nd amendment with electron donor; and
4. 3 to 18 weeks after the 3rd amendment with electron donor.

Limited baseline ORP data are available and the data from four of the wells (16EW12B, 16EW14B, 16PM04 and 16PM05) are pooled to provide a sufficient number of data points to allow an assessment of changes in ORP from the baseline values. It is considered reasonable to pool the ORP data from different wells before amendment with electron donor because the

mechanisms that impact the ORP values in the groundwater prior to addition of electron donor are believed to be generally consistent along the line of the biobarrier.

The mean and standard deviation of the ORP values from at least three time points in each of the time periods were calculated and are presented in Table F-9. In addition, a one-tailed Student's t-test analysis at a 95% confidence interval was conducted to test the null hypothesis that the ORP values at each of the three time periods did not decrease following amendment with electron donor relative to the baseline OPR. The t-test was performed using assuming unequal sample variance in the data sets. Table F-9 shows the p-statistic from the t-test for each of the time periods after baseline. The p-statistic provides a quantitative assessment of the confidence that the ORP data from the different time periods is in fact significantly different from the baseline ORP measurements.

The p-statistic for comparisons with baseline of each time period after baseline sampling is less that 0.02 for all tests and less that 0.006 for tests on data from all wells after the third amendment of electron donor. As these values are lower than 0.05 (i.e., the alpha value at 95% confidence), the null hypothesis is rejected, suggesting that the population of data from each subsequent time period is statistically different than that at the baseline. Given that the subsequent population means are lower than the mean at baseline, the t-test suggests that ORP concentrations are decreasing. The highest p-statistic values of 0.016 and 0.011 were calculated for comparisons of data from monitoring well 16PM04 in the time periods following the 1st and 2nd amendment of electron donor. Monitoring well 16PM04 is located in Transect 3 where it was recognized that there was less than optimal distribution of electron donor during the 1st and 2nd amendment of electron donor. The p-statistic for comparisons of ORP data for this well following the 3rd amendment of electron donor was 0.0024, demonstrating an even higher confidence (i.e., a lower p-statistic) that the 3rd amendment of electron donor reduced the ORP in the groundwater.

Figure F-1 presents the data used in this analysis on a time series chart that shows the magnitude of the change in the ORP values.

The statistical analysis of ORP data shows a high level of confidence that the injection of electron donor in the biobarrier resulted in significant reductions in ORP that are indicative of enhanced biological activity.

3. EVALUATION OF PERCHLORATE DATA

A statistical evaluation of perchlorate data collected from eleven key monitoring wells along the alignment of the biobarrier or within 25 feet (7.5 meters) of the alignment of the biobarrier was conducted. The wells selected for this evaluation consisted of:

1. 16PM05 and 16PM09 – in Transect 1;
2. 16EW14B – between Transect 1 and Transect 2;
3. 16PM06 and 16PM10-S - in Transect 2;

4. 16PM04, 16PM07-S and 16EW-10 - in Transect 3; and

5. 16EW12B, 16PM08 and 16PM11 - in Transect 4.

These wells are located along the alignment of the biobarrier or within about 25 feet (7.5 meters) of the biobarrier and were selected to represent wells that have been impacted by the amendment of electron donor. The geology at the site is highly variable and contains inter-bedded geological units or layers containing low and higher hydraulic conductivity material. Wells located further downgradient of the biobarrier are more likely to have been impacted perchlorate back-diffusing out of low hydraulic conductivity units downgradient of the biological activity of the biobarrier and they are more likely to have been impacted by groundwater passing around the biobarrier (i.e., 16PM12) or beneath the biobarrier (i.e., 16PM10-D).

Data from five different time periods were evaluated for the statistical analysis to represent different phases of the demonstration test. The specific periods of time were:

1. Baseline data before amendment with electron donor;

2. 2 to 6 weeks after the 1st amendment with electron donor;

3. 14 to 30 weeks after the 1st amendment with electron donor;

4. 4 to 20 after the 2nd amendment with electron donor; and

5. 3 to 18 weeks after the 3rd amendment with electron donor.

In this analysis, a value of one half the detection limit (0.002 mg/L) was used for samples reported by the lab as non-detect with a detection limit of 0.004 mg/L. Limited baseline perchlorate data are available but data from different locations were not pooled because the likely mechanisms that impact the perchlorate concentrations in the groundwater (i.e., release from specific locations in the landfill upgradient of the demonstration test area) may vary considerably within the demonstration test area.

The mean and standard deviation of the perchlorate concentrations from each of the time periods for each of the monitoring wells were calculated and are presented in Table F-10.

Figures F-2 and F-3 present the average perchlorate data for the different time periods for each of the monitoring wells on arithmetic and logarithmic scales.

Table F-11 shows the data for the final two time periods and for the final monitoring event along with the mean values for all the wells and the 90th percentile of the perchlorate data. The average concentrations and 90th percentile for perchlorate concentrations from Table F-11 are as follows:

	All Data Following the 3rd Amendment	Data from Final Monitoring Event
Average Concentration of Perchlorate (mg/L)	0.013	0.0039
90th Percentile Concentration of Perchlorate (mg/L)	0.023	0.0078

Some residual concentrations of perchlorate were detected during the final three sampling events. The average and 90th percentile data for the all data following the 3rd sampling event were strongly influenced by elevated data from the 30 January 2006 in monitoring wells 16PM06, 16PM10-S and 16PM07-S. The average and 90th percentile data for the final sampling event (March 2006) including data from monitoring wells 16PM06, 16PM10-S and 16PM07-S were 0.0039 and 0.0078 mg/L respectively.

TABLE F-9:STATISTICAL ANALYSIS OF ORP DATA
Site 16 Landfill, LHAAP, Karnack, Texas

Time Period	16PM05	Date	ORP	Mean	Standard Deviation	p-statistic from t-test
Before Amendment	16EW12B	24-Mar-04	223			
	16EW14B	24-Mar-04	206			
	16PM04	23-Mar-04	417			
	16PM05	24-Mar-04	216	265.5	101.2	
2-6 weeks after 1st Amendment	16PM05	4-May-04	18.1			
	16PM05	18-May-04	32.5			
	16PM05	2-Jun-04	47.8	33	14.9	0.0089
4-20 weeks after 2nd Amendment	16PM05	26-Jan-05	28.9			
	16PM05	9-Mar-05	-21.7			
	16PM05	24-May-05	-46.4	-13	38.4	0.0035
3-18 weeks after 3rd Amendment	16PM05	30-Jan-06	-35.8			
	16PM05	15-Mar-06	-37.0			
	16PM05	8-May-06	-22.2			
	16PM05	20-Jun-06	-26.4	-30	7.2	0.0049

Time Period	16EW14B	Date	ORP	Mean	Standard Deviation	p-statistic from t-test
Before Amendment	16EW12B	24-Mar-04	223			
	16EW14B	24-Mar-04	206			
	16PM04	23-Mar-04	417			
	16PM05	24-Mar-04	216	265.5	101.2	
2-6 weeks after 1st Amendment	16EW14B	5-May-04	-182			
	16EW14B	20-May-04	-99.3			
	16EW14B	4-Jun-04	-34.7	-105	73.8	0.0013
4-20 weeks after 2nd Amendment	16EW14B	26-Jan-05	-25.9			
	16EW14B	9-Mar-05	-178			
	16EW14B	25-May-05	-87.5	-97	76.5	0.0015

Time Period	16PM06	Date	ORP	Mean	Standard Deviation	p-statistic from t-test
Before Amendment	16EW12B	24-Mar-04	223			
	16EW14B	24-Mar-04	206			
	16PM04	23-Mar-04	417			
	16PM05	24-Mar-04	216	265.5	101.2	
2-6 weeks after 1st Amendment	16PM06	4-May-04	-33			
	16PM06	19-May-04	-62.2			
	16PM06	2-Jun-04	-47.7	-48	14.6	0.0038
4-20 weeks after 2nd Amendment	16PM06	26-Jan-05	6.5			
	16PM06	9-Mar-05	-6.2			
	16PM06	24-May-05	-48.5	-16	28.8	0.0040
3-18 weeks after 3rd Amendment	16PM06	30-Jan-06	-30.2			
	16PM06	14-Mar-06	-7.1			
	16PM06	8-May-06	-16.3			
	16PM06	20-Jun-06	5.4	-12	15.0	0.0055

TABLE F-9:STATISTICAL ANALYSIS OF ORP DATA
Site 16 Landfill, LHAAP, Karnack, Texas

Time Period	16PM04	Date	ORP	Mean	Standard Deviation	p-statistic from t-test
Before Amendment	16EW12B	24-Mar-04	223			
	16EW14B	24-Mar-04	206			
	16PM04	23-Mar-04	417			
	16PM05	24-Mar-04	216	265.5	101.2	
2-6 weeks after 1st Amendment	16PM04	4-May-04	114			
	16PM04	18-May-04	72.6			
	16PM04	3-Jun-04	65.1	84	26.3	0.0161
4-20 weeks after 2nd Amendment	16PM04	26-Jan-05	76.8			
	16PM04	10-Mar-05	31.2			
	16PM04	24-May-05	61.6	57	23.2	0.0111
3-18 weeks after 3rd Amendment	16PM04	30-Jan-06	-34.8			
	16PM04	15-Mar-06	-111			
	16PM04	8-May-06	-43.2			
	16PM04	20-Jun-06	-43.4	-58	35.5	0.0024

Time Period	16EW12B	Date	ORP	Mean	Standard Deviation	p-statistic from t-test
Before Amendment	16EW12B	24-Mar-04	223			
	16EW14B	24-Mar-04	206			
	16PM04	23-Mar-04	417			
	16PM05	24-Mar-04	216	265.5	101.2	
2-6 weeks after 1st Amendment	16EW12B	5-May-04	-20.5			
	16EW12B	20-May-04	-32.3			
	16EW12B	4-Jun-04	-34.5	-29	7.5	0.0049
4-20 weeks after 2nd Amendment	16EW12B	26-Jan-05	-57.4			
	16EW12B	9-Mar-05	-199			
	16EW12B	25-May-05	-236	-164	94.3	0.0014
3-18 weeks after 3rd Amendment	16EW12B	30-Jan-06	-311			
	16EW12B	16-Mar-06	-324			
	16EW12B	9-May-06	-322			
	16EW12B	22-Jun-06	-297	-314	12.4	0.0006

TABLE F-10: STATISTICAL ANALYSIS OF PERCHLORATE DATA
Site 16 Landfill, LHAAP, Karnack, Texas

Time Period	16PM05	Date	Perchlorate (mg/L)	Mean	Standard Deviation
Before Amendment	16PM05	24-Mar-04	**0.972**	0.972	
2-6 weeks after 1st Amendment	16PM05	4-May-04	**0.117**		
	16PM05	18-May-04	**0.134**		
	16PM05	2-Jun-04	**0.079**	0.110	0.028
14-30 weeks after 1st Amendment	16PM05	4-Aug-04	**0.011**		
	16PM05	29-Sep-04	**0.021**		
	16PM05	1-Dec-04	**0.016**	0.016	0.005
4-20 weeks after 2nd Amendment	16PM05	26-Jan-05	0.002		
	16PM05	10-Mar-05	**0.014**		
	16PM05	24-May-05	**0.092**	0.036	0.049
3-18 weeks after 3rd Amendment	16PM05	19-Dec-05	0.002		
	16PM05	30-Jan-06	0.002		
	16PM05	15-Mar-06	0.002	0.002	0.000

Time Period	16PM09	Date	Perchlorate (mg/L)	Mean	Standard Deviation
Before Amendment	16PM09	24-Mar-04	**0.918**	0.918	
2-6 weeks after 1st Amendment	16PM09	4-May-04	**0.239**		
	16PM09	18-May-04	**0.146**		
	16PM09	2-Jun-04	**0.148**	0.178	0.053
14-30 weeks after 1st Amendment	16PM09	4-Aug-04	**0.059**		
	16PM09	29-Sep-04	**0.029**		
	16PM09	1-Dec-04	**0.022**	0.037	0.020
4-20 weeks after 2nd Amendment	16PM09	26-Jan-05	**0.038**		
	16PM09	10-Mar-05	**0.006**		
	16PM09	24-May-05	**0.014**	0.019	0.017
3-18 weeks after 3rd Amendment	16PM09	19-Dec-05	0.002		
	16PM09	30-Jan-06	0.002		
	16PM09	15-Mar-06	0.002	0.002	0.000

Time Period	16EW14B	Date	Perchlorate (mg/L)	Mean	Standard Deviation
Before Amendment	16EW14B	24-Mar-04	**1.000**	1.000	
2-6 weeks after 1st Amendment	16EW14B	5-May-04	0.002		
	16EW14B	20-May-04	**0.142**		
	16EW14B	4-Jun-04	**0.0298**	0.058	0.074
14-30 weeks after 1st Amendment	16EW14B	4-Aug-04	**0.0144**		
	16EW14B	29-Sep-04	**0.0707**		
	16EW14B	2-Dec-04	**0.0376**	0.041	0.028
4-20 weeks after 2nd Amendment	16EW14B	26-Jan-05	0.002		
	16EW14B	10-Mar-05	0.002		
	16EW14B	25-May-05	0.002	0.002	0.000

TABLE F-10: STATISTICAL ANALYSIS OF PERCHLORATE DATA
Site 16 Landfill, LHAAP, Karnack, Texas

Time Period	16PM06	Date	Perchlorate (mg/L)	Mean	Standard Deviation
Before Amendment	16PM06	23-Mar-04	**0.968**	0.968	
2-6 weeks	16PM06	4-May-04	**0.040**		
after 1st	16PM06	19-May-04	**0.374**		
Amendment	16PM06	2-Jun-04	**0.092**	0.169	0.180
14-30 weeks	16PM06	4-Aug-04	**0.006**		
after 1st	16PM06	30-Sep-04	**0.041**		
Amendment	16PM06	1-Dec-04	**0.007**	0.018	0.020
4-20 weeks	16PM06	26-Jan-05	0.002		
after 2nd	16PM06	10-Mar-05	0.002		
Amendment	16PM06	24-May-05	0.002	0.002	0.000
3-18 weeks	16PM06	19-Dec-05	0.002		
after 3rd	16PM06	30-Jan-06	**0.098**		
Amendment	16PM06	14-Mar-06	**0.007**	0.036	0.054

Time Period	16PM10-S	Date	Perchlorate (mg/L)	Mean	Standard Deviation
Before Amendment	16PM10-S	24-Mar-04	**0.669**	0.669	
2-6 weeks	16PM10-S	4-May-04	**0.051**		
after 1st	16PM10-S	19-May-04	**0.340**		
Amendment	16PM10-S	3-Jun-04	**0.062**	0.151	0.164
14-30 weeks	16PM10-S	4-Aug-04	**0.026**		
after 1st	16PM10-S	30-Sep-04	0.002		
Amendment	16PM10-S	1-Dec-04	**0.0087**	0.012	0.012
4-20 weeks	16PM10-S	26-Jan-05	0.002		
after 2nd	16PM10-S	10-Mar-05	0.002		
Amendment	16PM10-S	24-May-05	0.002	0.002	0.000
3-18 weeks	16PM10-S	19-Dec-05	0.002		
after 3rd	16PM10-S	30-Jan-06	**0.106**		
Amendment	16PM10-S	14-Mar-06	**0.0075**	0.039	0.059

TABLE F-10: STATISTICAL ANALYSIS OF PERCHLORATE DATA
Site 16 Landfill, LHAAP, Karnack, Texas

Time Period	16PM04	Date	Perchlorate (mg/L)	Mean	Standard Deviation
Before Amendment	16PM04	23-Mar-04	**0.286**	0.286	
2-6 weeks after 1st Amendment	16PM04	4-May-04	**0.202**		
	16PM04	18-May-04	**0.164**		
	16PM04	3-Jun-04	**0.106**	0.157	0.048
14-30 weeks after 1st Amendment	16PM04	4-Aug-04	**0.064**		
	16PM04	30-Sep-04	**0.068**		
	16PM04	1-Dec-04	**0.030**	0.054	0.021
4-20 weeks after 2nd Amendment	16PM04	26-Jan-05	**0.004**		
	16PM04	10-Mar-05	**0.014**		
	16PM04	24-May-05	**0.044**	0.021	0.021
3-18 weeks after 3rd Amendment	16PM04	19-Dec-05	0.002		
	16PM04	30-Jan-06	0.002		
	16PM04	15-Mar-06	0.002	0.002	0.000

Time Period	16PM07-S	Date	Perchlorate (mg/L)	Mean	Standard Deviation
Before Amendment	16PM07-S	23-Mar-04	**0.039**	0.039	
2-6 weeks after 1st Amendment	16PM07-S	4-May-04	**0.095**		
	16PM07-S	19-May-04	**0.177**		
	16PM07-S	3-Jun-04	**0.060**	0.111	0.060
14-30 weeks after 1st Amendment	16PM07-S	4-Aug-04	**0.086**		
	16PM07-S	30-Sep-04	**0.076**		
	16PM07-S	1-Dec-04	**0.0055**	0.056	0.044
4-20 weeks after 2nd Amendment	16PM07-S	26-Jan-05	0.002		
	16PM07-S	10-Mar-05	0.002		
	16PM07-S	24-May-05	0.002	0.002	0.000
3-18 weeks after 3rd Amendment	16PM07-S	19-Dec-05	0.002		
	16PM07-S	30-Jan-06	**0.073**		
	16PM07-S	14-Mar-06	**0.010**	0.028	0.039

Time Period	16EW10	Date	Perchlorate (mg/L)	Mean	Standard Deviation
Before Amendment	16EW10	23-Mar-04	**0.111**	0.111	
2-6 weeks after 1st Amendment	16EW10	5-May-04	**0.076**		
	16EW10	20-May-04	**0.193**		
	16EW10	4-Jun-04	**0.074**	0.114	0.068
14-30 weeks after 1st Amendment	16EW10	4-Aug-04	**0.130**		
	16EW10	29-Sep-04	**0.110**		
	16EW10	2-Dec-04	**0.031**	0.090	0.052
4-20 weeks after 2nd Amendment	16EW10	26-Jan-05	**0.0053**		
	16EW10	10-Mar-05	**0.055**		
	16EW10	25-May-05	0.002	0.021	0.029
3-18 weeks after 3rd Amendment	16EW10	19-Dec-05	0.002		
	16EW10	30-Jan-06	0.002		
	16EW10	15-Mar-06	0.002	0.002	0.000

TABLE F-10: STATISTICAL ANALYSIS OF PERCHLORATE DATA
Site 16 Landfill, LHAAP, Karnack, Texas

Time Period	16EW12B	Date	Perchlorate (mg/L)	Mean	Standard Deviation
Before Amendment	16EW12B	24-Mar-04	**1.04**	1.040	
2-6 weeks after 1st Amendment	16EW12B	5-May-04	**0.103**		
	16EW12B	20-May-04	**0.063**		
	16EW12B	4-Jun-04	**0.061**	0.076	0.024
14-30 weeks after 1st Amendment	16EW12B	4-Aug-04	**0.033**		
	16EW12B	29-Sep-04	**0.065**		
	16EW12B	2-Dec-04	**0.018**	0.039	0.024
4-20 weeks after 2nd Amendment	16EW12B	26-Jan-05	0.002		
	16EW12B	10-Mar-05	**0.022**		
	16EW12B	25-May-05	0.002	0.009	0.012
3-18 weeks after 3rd Amendment	16EW12B	19-Dec-05	0.002		
	16EW12B	30-Jan-06	**0.018**		
	16EW12B	16-Mar-06	0.002	0.007	0.009

Time Period	16PM08	Date	Perchlorate (mg/L)	Mean	Standard Deviation
Before Amendment	16PM08	23-Mar-04	**0.129**	0.129	
2-6 weeks after 1st Amendment	16PM08	5-May-04	**0.111**		
	16PM08	19-May-04	**0.126**		
	16PM08	3-Jun-04	**0.089**	0.109	0.018
14-30 weeks after 1st Amendment	16PM08	4-Aug-04	**0.035**		
	16PM08	30-Sep-04	**0.064**		
	16PM08	1-Dec-04	**0.030**	0.043	0.018
4-20 weeks after 2nd Amendment	16PM08	26-Jan-05	**0.073**		
	16PM08	10-Mar-05	**0.032**		
	16PM08	24-May-05	**0.025**	0.043	0.026
3-18 weeks after 3rd Amendment	16PM08	19-Dec-05	0.002		
	16PM08	31-Jan-06	**0.004**		
	16PM08	14-Mar-06	0.002	0.003	0.001

Time Period	16PM11	Date	Perchlorate (mg/L)	Mean	Standard Deviation
Before Amendment	16PM11	23-Mar-04	**0.161**	0.161	
2-6 weeks after 1st Amendment	16PM11	4-May-04	**0.191**		
	16PM11	20-May-04	**0.258**		
	16PM11	3-Jun-04	**0.140**	0.196	0.059
14-30 weeks after 1st Amendment	16PM11	4-Aug-04	**0.068**		
	16PM11	30-Sep-04	**0.135**		
	16PM11	1-Dec-04	**0.041**	0.082	0.048
4-20 weeks after 2nd Amendment	16PM11	26-Jan-05	**0.039**		
	16PM11	10-Mar-05	**0.022**		
	16PM11	24-May-05	**0.017**	0.026	0.012
3-18 weeks after 3rd Amendment	16PM11	19-Dec-05	0.002		
	16PM11	31-Jan-06	**0.014**		
	16PM11	14-Mar-06	0.002	0.006	0.007

Figure F-1
Reduction in ORP Over Time - Biobarrier Wells

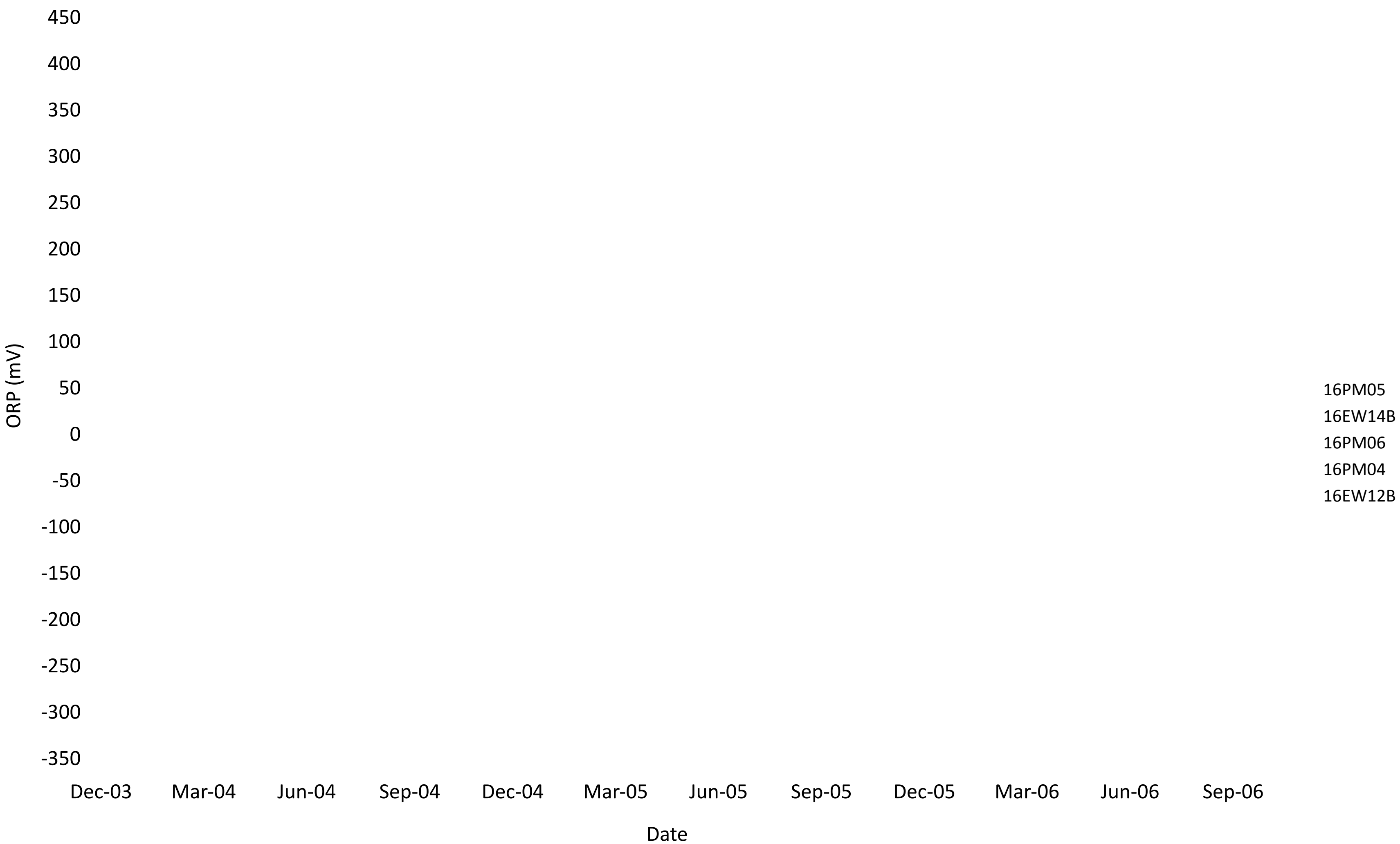


Figure F-2

Average Perchlorate Concentrations Over Time (arithmetic scale)

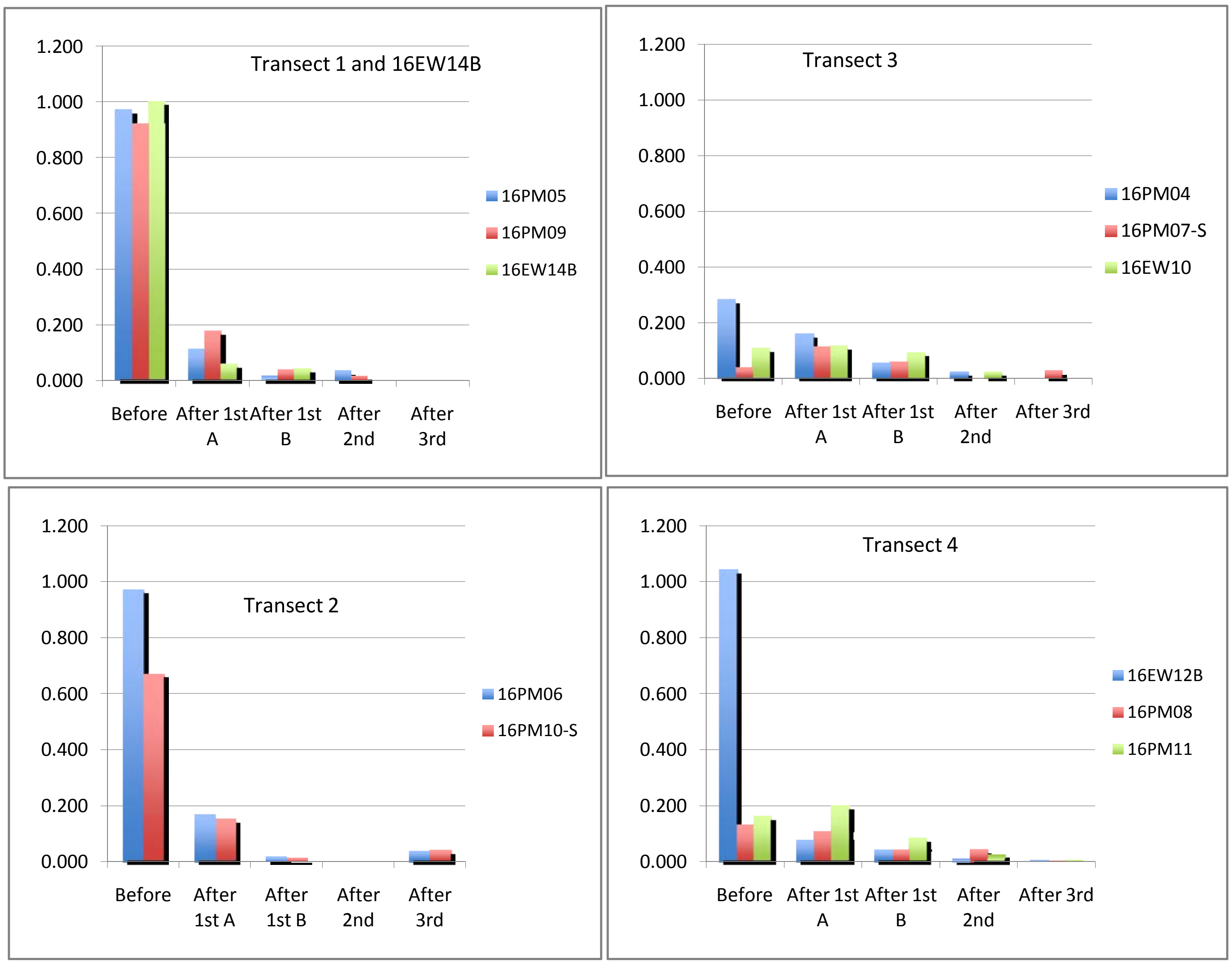
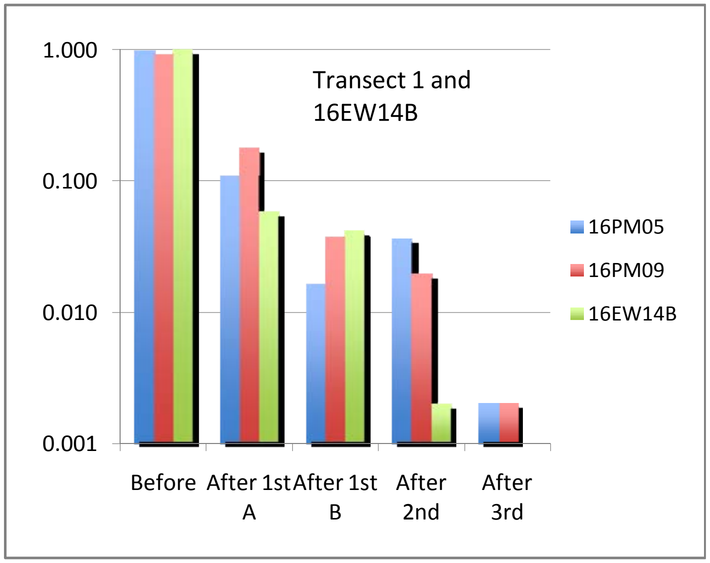
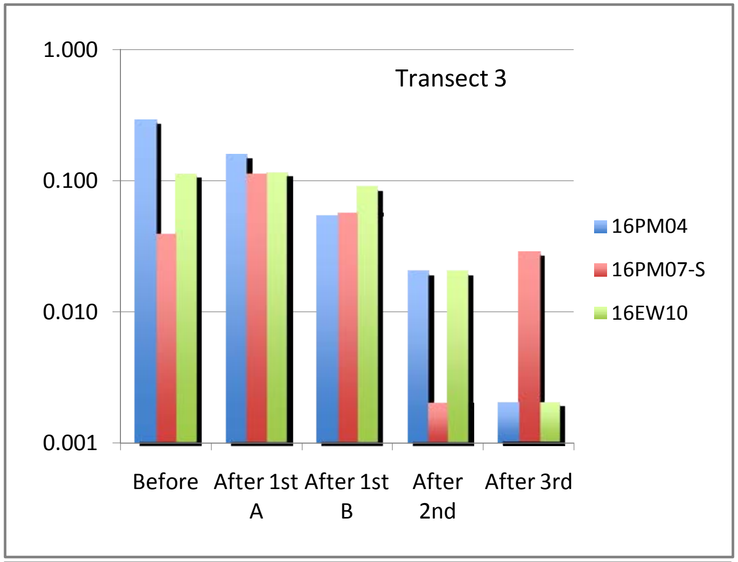
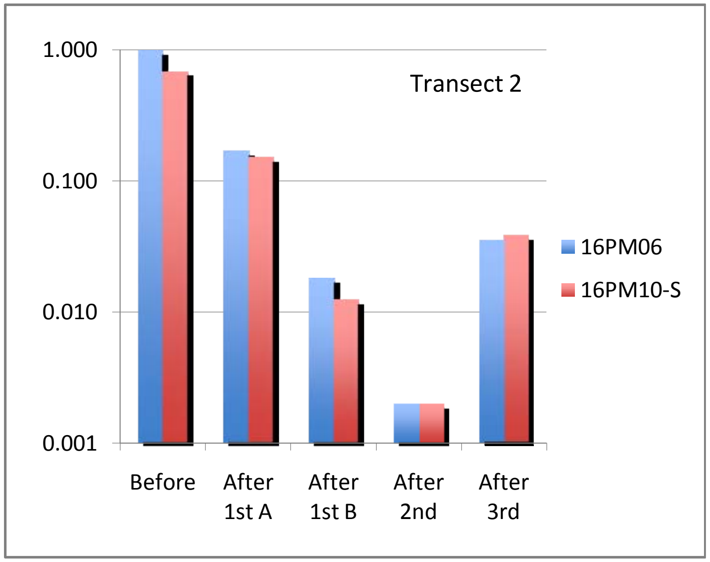


Figure F-2
Average Perchlorate Concentrations Over Time (log scale)







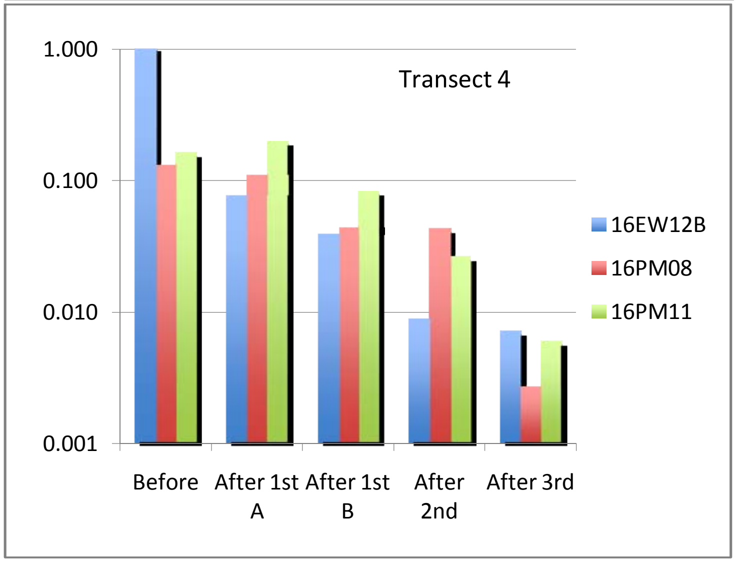


TABLE F-11: AVERAGE CONCENTRATIONS OF PERCHLORATE IN DIFFERENT TIME PERIODS
Site 16 Landfill, LHAAP, Karnack, Texas

Well	Date	Perchlorate (mg/L)	Mean	Standard Deviation	90th Percentile
Data Following the 2nd Amendment					
16PM05	26-Jan-05	0.002			
16PM05	10-Mar-05	**0.0137**			
16PM05	24-May-05	**0.092**			
16PM09	26-Jan-05	**0.038**			
16PM09	10-Mar-05	**0.006**			
16PM09	24-May-05	**0.0135**			
16EW14B	26-Jan-05	0.002			
16EW14B	10-Mar-05	0.002			
16EW14B	25-May-05	0.002			
16PM06	26-Jan-05	0.002			
16PM06	10-Mar-05	0.002			
16PM06	24-May-05	0.002			
16PM10-S	26-Jan-05	0.002			
16PM10-S	10-Mar-05	0.002			
16PM10-S	24-May-05	0.002			
16PM04	26-Jan-05	**0.004**			
16PM04	10-Mar-05	**0.01395**			
16PM04	24-May-05	**0.0439**			
16PM07-S	26-Jan-05	0.002			
16PM07-S	10-Mar-05	0.002			
16PM07-S	24-May-05	0.002			
16EW10	26-Jan-05	**0.0053**			
16EW10	10-Mar-05	**0.0546**			
16EW10	25-May-05	0.002			
16EW12B	26-Jan-05	0.002			
16EW12B	10-Mar-05	**0.0223**			
16EW12B	25-May-05	0.002			
16PM08	26-Jan-05	**0.0732**			
16PM08	10-Mar-05	**0.03175**			
16PM08	24-May-05	**0.0245**			
16PM11	26-Jan-05	**0.0391**			
16PM11	10-Mar-05	**0.0219**			
16PM11	24-May-05	**0.0171**	0.0166	0.0225	0.0429

TABLE F-11: AVERAGE CONCENTRATIONS OF PERCHLORATE IN DIFFERENT TIME PERIODS
Site 16 Landfill, LHAAP, Karnack, Texas

Well	Date	Perchlorate (mg/L)	Mean	Standard Deviation	90th Percentile
All Data Following the 3rd Amendmen					
16PM05	19-Dec-05	0.002			
16PM05	30-Jan-06	0.002			
16PM05	15-Mar-06	0.002			
16PM09	19-Dec-05	0.002			
16PM09	30-Jan-06	0.002			
16PM09	15-Mar-06	0.002			
16PM06	19-Dec-05	0.002			
16PM06	30-Jan-06	**0.098**			
16PM06	14-Mar-06	**0.007**			
16PM10-S	19-Dec-05	0.002			
16PM10-S	30-Jan-06	**0.106**			
16PM10-S	14-Mar-06	**0.0075**			
16PM04	19-Dec-05	0.002			
16PM04	30-Jan-06	0.002			
16PM04	15-Mar-06	0.002			
16PM07-S	19-Dec-05	0.002			
16PM07-S	30-Jan-06	**0.073**			
16PM07-S	14-Mar-06	**0.01**			
16EW10	19-Dec-05	0.002			
16EW10	30-Jan-06	0.002			
16EW10	15-Mar-06	0.002			
16EW12B	19-Dec-05	0.002			
16EW12B	30-Jan-06	**0.0175**			
16EW12B	16-Mar-06	0.002			
16PM08	19-Dec-05	0.002			
16PM08	31-Jan-06	**0.004**			
16PM08	14-Mar-06	0.002			
16PM11	19-Dec-05	0.002			
16PM11	31-Jan-06	**0.014**			
16PM11	14-Mar-06	0.002	0.0126	0.0277	0.0231
Data from Final Monitoring Event					
16PM05	15-Mar-06	0.002			
16PM09	15-Mar-06	0.002			
16PM06	14-Mar-06	**0.007**			
16PM10-S	14-Mar-06	**0.0075**			
16PM04	15-Mar-06	0.002			
16PM07-S	14-Mar-06	**0.01**			
16EW10	15-Mar-06	0.002			
16EW12B	16-Mar-06	0.002			
16PM08	14-Mar-06	0.002			
16PM11	14-Mar-06	0.002	0.0039	0.0031	0.0078

Geosyntec consultants

APPENDIX G

MICROBIAL CHARACTERIZATION REPORTS

Sample Analysis Report

Longhorn Texas Army Ammunition Plant

Submitted to

Evan Cox

GeoSyntec Consultants
130 Research Lane
Guelph, Ontario, N1G 5G3
Phone: 519-822-2230

By

John D. Coates

July 30, 2003

Enumeration studies. The perchlorate-reducing population in the samples were enumerated by most probable number counts (MPNs) with acetate (5 mM) as the electron donor and ammonium perchlorate (5 mM) as the electron acceptor. Anaerobic basal medium, was prepared under a headspace of N_2-CO_2 (80-20, vol/vol.) using standard anaerobic techniques, and amended with ammonium perchlorate (5 mM) or nitrate (5 mM) as the electron acceptor respectively and acetate (10 mM) as the electron donor. Positives in the MPN series were identified by visual observation of optical density increase.

Site Name	**MPN(ClO_4^-) (Cells/mL)**
BH-4 (28 foot)	ND[a]
BH-4 (23 foot)	ND
BH-4 (18 foot)	ND
BH-2 (27 foot)	ND
BH-2 (18 foot)	ND
BH-2 (13 foot)	ND
BH-2 (8 foot)	ND
Well Water (BH-2)	ND

[a] ND None detected

Geochemical Analysis. Samples were analyzed for the presence of nitrate, sulfate, chloride, chlorate, and chlorite by ion chromatography. The concentration of perchlorate in samples were determined by ion chromatography coupled to suppressed conductivity using a Dionex IonPac AS 11 4x250mm column (Dionex Corporation, Sunnyvale, CA) with a 100 mM NaOH mobile phase at a flow rate of 1mL min^{-1}. The eluting perchlorate was detected by a conductivity detector (Shimadzu model: CDD -6A) suppressed with a Dionex ASRS-Ultra operating in external water mode set at 300 mA. Chlorate, chloride, nitrate, and nitrite in the culture medium were determined using a Dionex DX500 ion chromatograph (Dionex Corporation, Sunnyvale, CA) equipped with a GP50 gradient pump, CD20

Site/ Depth	**Cl^- [mM]**	**ClO_3^- [μM]**	**ClO_4^- [μM]**	**NO_3^- [μM]**	**PO_4^{3-} [μM]**	**SO_4^{2-} [mM]**
BH-4 (28 foot)	12.02	22	2.041	43.33	0	0.2967
BH-4 (23 foot)	7.875	5.333	0	2	0	0.282
BH-4 (18 foot)	8.859	12	0	0	0.6667	0.06867
BH-2 (27 foot)	6.977	18.67	0	26	0	7.251
BH-2 (18 foot)	7.313	14.67	0	11.33	0	5.493
BH-2 (13 foot)	0	16.67	1.451	1.333	0	2.835
BH-2 (8 foot)	7.673	6.667	3.279	73.33	13.33	0.4893
Well Water (BH-2)	42.96	98.67	0	116	0	53.83

An IonPac AS9-SC 4x250 mm column was used for analysis with bicarbonate buffer containing 2 mM sodium carbonate and 0.75 mM sodium bicarbonate at a flow rate of 2 (mL min^{-1}) as the eluent. The SRS current was set at 100 mA for all the analysis. Chlorite were not detected in any samples. Unexpectedly, chlorate was !!!!

Site/ Depth	**pH**	**HS^{-} [μM]**
BH-4 (28 foot)	7.14	0
BH-4 (23 foot)	7.18	0
BH-4 (18 foot)	6.84	0
BH-2 (27 foot)	6.99	0
BH-2 (18 foot)	7.28	0
BH-2 (13 foot)	7.09	0
BH-2 (8 foot)	6.85	0
Well Water (BH-2)	8.2	0

Organic volatile fatty acid analyses. Acetate, propionate, and butyrate concentrations were determined by HPLC (Shimadzu, Model: SPD-10A), equipped with UV-VIS detector, at a wavelength of 210 nm using a HL-75H^{+} cation-exchange column (Hamilton, Model no. 79476) and a mobile phase of 0.016 N H_2SO_4 at a flow rate of 0.4 mL min^{-1}.

Site Name	**Acetate (μM)**	**Propionate (μM)**	**Lactate (μM)**
BH-4 (28 foot)	6.69	0	0
BH-4 (23 foot)	0	0	0
BH-4 (18 foot)	0	0	0
BH-2 (27 foot)	0	0	0
BH-2 (18 foot)	0	0	0
BH-2 (13 foot)	0	0	0
BH-2 (8 foot)	0	0	0
Well Water (BH-2)	0	0	0

Ferrous (Fe(II)), ferric (Fe(III)) iron and aqueous manganese (Mn(II)) analyses. The Fe(II) and Fe(III) content of samples was analyzed by standard colorimetric assay with ferrozine after extraction in 0.5 M HCl and measuring the absorbance at 562 nm. The Mn(II) content was analyzed by standard colorimetric assay with formaldoxime and the absorbance was measured at 450 nm.

Site Name	**Fe^{2+} (mM)**	**Soluble Fe^{2+} (mM)**	**Fe^{3+} (mM)**	**Aqueous Mn(II) (μM)**
BH-4 (28 foot)	0.1373	0.003091	2.769	0.1018
BH-4 (23 foot)	0.08864	0.009697	1.204	0.6573
BH-4 (18 foot)	0.2739	0.06299	7.755	0.3095
BH-2 (27 foot)	1.494	0.02553	6.678	26.27
BH-2 (18 foot)	1.894	0.002442	0.757	0
BH-2 (13 foot)	0.1521	0.0266	1.691	17.29
BH-2 (8 foot)	0.3834	0	6.385	0.05672
Well Water (BH-2)	0.1124	0.02193	13.44	48.57

Identification of the dominant perchlorate-reducers by molecular analysis. The predominant perchlorate-reducing bacteria in the samples was determined by extracting the genomic DNA and amplifying the 16S rDNA by polymerase chain reaction (PCR) using 16S rDNA probes specific to the *Dechloromonas* and *Dechlorosoma* groups which are the known to be the dominant perchlorate-reducers in most environments. Positives were identified by the presence of PCR amplification products in agarose electrophoresis gels.

		Dechloromonas		***Dechlorosoma***
Site Number- Depth	**Universal Primers (control)**	**CKB Primers**	**RCB Primers**	**PS Primers**
BH-4 (28 foot)	(+)	(-)	(+)	(-)
BH-4 (23 foot)	(+)	(+)	(+)	(-)
BH-4 (18 foot)	(+)	(-)	(-)	(-)
BH-2 (27 foot)	(+)	(-)	(-)	(-)
BH-2 (18 foot)	(+)	(-)	(-)	(-)
BH-2 (13 foot)	(+)	(-)	(-)	(-)
BH-2 (8 foot)	(+)	(-)	(-)	(-)
Well Water (BH-2)	(+)	(-)	(-)	(-)

(+) means 16S DNA was successfully amplified.
(-) means no 16S DNA was amplified.

These results demonstrate that *Dechlorosoma* species are not prevalent in the Longhorn Texas site and that *Dechloromonas* species were only detectable in samples collected from BH-4 cores at 23 and 28 foot depths. These results support the enumeration studies which indicated that perchlorate-reducing populations were below detection (< 10 cells g^{-1} sample) in the samples.

Geosyntec consultants

APPENDIX H

TRACER TEST DATA

TABLE H-1: RESULTS OF TRACER TEST (Winter 2004) ANIONS ANALYSIS.
Site 16 Landfill, LHAAP, Karnack, Texas

			Concentration (mg/L)	
Location	Date Sampled	Analysis	Iodide	Bromide
16EW09	27-Mar-03	Laboratory		**3.36**
16EW09	24-Mar-04	Laboratory		6.00 U
16EW09	29-Sep-04	Laboratory		**9.46**
16EW09	26-Jan-05	Laboratory		**8.26**
16EW10	27-Mar-03	Laboratory		**6.65**
16EW10	19-Feb-04	Field Electrode	0.500 U	
16EW10	20-Feb-04	Field Electrode	0.500 U	
16EW10	22-Feb-04	Field Electrode	0.500 U	
16EW10	23-Feb-04	Field Electrode	0.500 U	
16EW10	24-Feb-04	Field Electrode	0.500 U	
16EW10	25-Feb-04	Field Electrode	0.500 U	
16EW10	26-Feb-04	Field Electrode	0.500 U	
16EW10	27-Feb-04	Field Electrode	0.500 U	
16EW10	28-Feb-04	Field Electrode	0.500 U	
16EW10	1-Mar-04	Field Electrode	0.500 U	
16EW10	2-Mar-04	Field Electrode	0.500 U	
16EW10	3-Mar-04	Field Electrode	0.500 U	
16EW10	5-Mar-04	Field Electrode	0.500 U	
16EW10	8-Mar-04	Field Electrode	0.500 U	
16EW10	10-Mar-04	Field Electrode	0.500 U	
16EW10	12-Mar-04	Field Electrode	0.500 U	
16EW10	15-Mar-04	Field Electrode	0.500 U	
16EW10	17-Mar-04	Field Electrode	0.500 U	
16EW10	19-Mar-04	Field Electrode	0.500 U	
16EW10	23-Mar-04	Laboratory		**7.01**
16EW10	24-Mar-04	Field Electrode	0.500 U	
16EW10	6-Apr-04	Field Electrode	0.500 U	
16EW10	29-Sep-04	Laboratory		**9.99**
16EW10	26-Jan-05	Laboratory		**7.88**
16EW11	27-Mar-03	Laboratory		**3.67**
16EW11	6-Apr-04	Field Electrode	0.500 U	
16EW12	30-Jun-03	Laboratory		**0.77**
16EW12	25-Mar-04	Field Electrode	0.500 U	
16EW12	25-Mar-04	Field Electrode		0.500 U
16EW12	6-Apr-04	Field Electrode	0.500 U	
16EW12	06-Apr-04	Field Electrode		0.500 U
16EW12B	10-Feb-04	Field Electrode	0.500 U	
16EW12B	10-Feb-04	Field Electrode		0.500 U
16EW12B	11-Feb-04	Field Electrode		0.500 U
16EW12B	11-Feb-04	Field Electrode		**510**
16EW12B	11-Feb-04	Laboratory		**559**
16EW12B	12-Feb-04	Field Electrode		**481**
16EW12B	12-Feb-04	Laboratory		**513**
16EW12B	12-Feb-04	Field Electrode		**486**
16EW12B	12-Feb-04	Laboratory		**517**
16EW12B	13-Feb-04	Field Electrode		**539**
16EW12B	13-Feb-04	Field Electrode		**512**
16EW12B	14-Feb-04	Field Electrode		**473**
16EW12B	14-Feb-04	Field Electrode		**477**
16EW12B	15-Feb-04	Field Electrode		**528**
16EW12B	15-Feb-04	Field Electrode		**467**
16EW12B	15-Feb-04	Laboratory		**500**
16EW12B	16-Feb-04	Field Electrode		**532**

			Concentration (mg/L)	
Location	Date Sampled	Analysis	Iodide	Bromide
16PM09	26-Jun-03	Laboratory		0.600 U
16PM09	10-Feb-04	Field Electrode		0.500 U
16PM09	12-Feb-04	Field Electrode		0.500 U
16PM09	13-Feb-04	Field Electrode		0.500 U
16PM09	13-Feb-04	Field Electrode		0.500 U
16PM09	14-Feb-04	Field Electrode		0.500 U
16PM09	15-Feb-04	Field Electrode		0.500 U
16PM09	15-Feb-04	Field Electrode		0.500 U
16PM09	16-Feb-04	Field Electrode		0.500 U
16PM09	17-Feb-04	Field Electrode		**2**
16PM09	18-Feb-04	Field Electrode		0.500 U
16PM09	18-Feb-04	Laboratory		**1.2**
16PM09	18-Feb-04	Field Electrode		0.500 U
16PM09	19-Feb-04	Field Electrode		**1.1**
16PM09	20-Feb-04	Field Electrode		0.500 U
16PM09	22-Feb-04	Field Electrode		0.500 U
16PM09	22-Feb-04	Laboratory		**1.9**
16PM09	23-Feb-04	Field Electrode		**4.8**
16PM09	24-Feb-04	Field Electrode		**7.3**
16PM09	25-Feb-04	Field Electrode		**17.4**
16PM09	25-Feb-04	Laboratory		**14**
16PM09	26-Feb-04	Field Electrode		**23.2**
16PM09	27-Feb-04	Field Electrode		**19.3**
16PM09	28-Feb-04	Field Electrode		**23.9**
16PM09	01-Mar-04	Field Electrode		**25.3**
16PM09	02-Mar-04	Field Electrode		**42.2**
16PM09	03-Mar-04	Field Electrode		**30.4**
16PM09	03-Mar-04	Laboratory		**29**
16PM09	05-Mar-04	Field Electrode		**46.6**
16PM09	08-Mar-04	Field Electrode		**44**
16PM09	08-Mar-04	Laboratory		**31**
16PM09	10-Mar-04	Field Electrode		**47.9**
16PM09	12-Mar-04	Field Electrode		**49.8**
16PM09	15-Mar-04	Field Electrode		**43.5**
16PM09	17-Mar-04	Field Electrode		**48.6**
16PM09	19-Mar-04	Field Electrode		**39.6**
16PM09	24-Mar-04	Laboratory		**38**
16PM09	24-Mar-04	Field Electrode		**30.4**
16PM09	06-Apr-04	Field Electrode		**44.4**
16PM09	29-Sep-04	Laboratory		**9.46**
16PM09	26-Jan-05	Laboratory		**8.06**
16PM10-D	27-Jun-03	Laboratory		**1.25**
16PM10-D	15-Feb-04	Field Electrode	0.500 U	
16PM10-D	16-Feb-04	Field Electrode	0.500 U	
16PM10-D	17-Feb-04	Field Electrode	0.500 U	
16PM10-D	18-Feb-04	Field Electrode	0.500 U	
16PM10-D	18-Feb-04	Laboratory	2.50 U	
16PM10-D	19-Feb-04	Field Electrode	0.500 U	
16PM10-D	20-Feb-04	Field Electrode	0.500 U	
16PM10-D	22-Feb-04	Field Electrode	0.500 U	
16PM10-D	22-Feb-04	Laboratory	2.50 U	
16PM10-D	23-Feb-04	Field Electrode	0.500 U	
16PM10-D	24-Feb-04	Field Electrode	0.500 U	

TABLE H-1: RESULTS OF TRACER TEST (Winter 2004) ANIONS ANALYSIS.
Site 16 Landfill, LHAAP, Karnack, Texas

			Concentration (mg/L)	
Location	Date Sampled	Analysis	Iodide	Bromide
16EW12B	16-Feb-04	Laboratory		**453**
16EW12B	16-Feb-04	Field Electrode		**425**
16EW12B	16-Feb-04	Field Electrode		**477**
16EW12B	17-Feb-04	Field Electrode		**483**
16EW12B	17-Feb-04	Field Electrode		**9**
16EW12B	18-Feb-04	Field Electrode		0.500 U
16EW12B	18-Feb-04	Field Electrode		0.500 U
16EW12B	18-Feb-04	Laboratory		0.140 U
16EW12B	19-Feb-04	Field Electrode		0.500 U
16EW12B	20-Feb-04	Field Electrode		0.500 U
16EW12B	22-Feb-04	Field Electrode		0.500 U
16EW12B	23-Feb-04	Field Electrode		**5.5**
16EW12B	24-Feb-04	Field Electrode	0.500 U	
16EW12B	24-Feb-04	Field Electrode		0.500 U
16EW12B	25-Feb-04	Field Electrode	0.500 U	
16EW12B	25-Feb-04	Field Electrode		0.500 U
16EW12B	26-Feb-04	Field Electrode	0.500 U	
16EW12B	26-Feb-04	Field Electrode		0.500 U
16EW12B	27-Feb-04	Field Electrode	0.500 U	
16EW12B	27-Feb-04	Field Electrode		0.500 U
16EW12B	28-Feb-04	Field Electrode	0.500 U	
16EW12B	28-Feb-04	Field Electrode		0.500 U
16EW12B	01-Mar-04	Field Electrode		**21.3**
16EW12B	02-Mar-04	Field Electrode		0.500 U
16EW12B	2-Mar-04	Field Electrode	0.500 U	
16EW12B	3-Mar-04	Field Electrode	0.500 U	
16EW12B	03-Mar-04	Field Electrode		0.500 U
16EW12B	4-Mar-04	Field Electrode	0.500 U	
16EW12B	04-Mar-04	Field Electrode		0.500 U
16EW12B	05-Mar-04	Field Electrode		0.500 U
16EW12B	6-Mar-04	Field Electrode	0.500 U	
16EW12B	06-Mar-04	Field Electrode		0.500 U
16EW12B	8-Mar-04	Field Electrode	0.500 U	
16EW12B	08-Mar-04	Field Electrode		0.500 U
16EW12B	9-Mar-04	Field Electrode	0.500 U	
16EW12B	09-Mar-04	Field Electrode		0.500 U
16EW12B	10-Mar-04	Field Electrode	0.500 U	
16EW12B	10-Mar-04	Field Electrode		0.500 U
16EW12B	12-Mar-04	Field Electrode	0.500 U	
16EW12B	12-Mar-04	Field Electrode		0.500 U
16EW12B	15-Mar-04	Field Electrode	0.500 U	
16EW12B	15-Mar-04	Field Electrode		**1.6**
16EW12B	15-Mar-04	Field Electrode		0.500 U
16EW12B	17-Mar-04	Field Electrode	0.500 U	
16EW12B	19-Mar-04	Field Electrode	0.500 U	
16EW12B	19-Mar-04	Field Electrode		0.500 U
16EW12B	24-Mar-04	Laboratory		**6.2**
16EW12B	24-Mar-04	Field Electrode	0.500 U	
16EW12B	24-Mar-04	Field Electrode		**12.6**
16EW12B	29-Sep-04	Laboratory		**3.45**
16EW12B	26-Jan-05	Laboratory		**2.87**
16EW13	26-Jun-03	Laboratory		0.600 U
16EW13	6-Apr-04	Field Electrode	**2.38**	

			Concentration (mg/L)	
Location	Date Sampled	Analysis	Iodide	Bromide
16PM10-D	25-Feb-04	Field Electrode	0.500 U	
16PM10-D	26-Feb-04	Field Electrode	0.500 U	
16PM10-D	27-Feb-04	Field Electrode	0.500 U	
16PM10-D	28-Feb-04	Field Electrode	0.500 U	
16PM10-D	1-Mar-04	Field Electrode	0.500 U	
16PM10-D	2-Mar-04	Field Electrode	0.500 U	
16PM10-D	3-Mar-04	Field Electrode	0.500 U	
16PM10-D	5-Mar-04	Field Electrode	0.500 U	
16PM10-D	8-Mar-04	Field Electrode	0.500 U	
16PM10-D	10-Mar-04	Field Electrode	0.500 U	
16PM10-D	12-Mar-04	Field Electrode	0.500 U	
16PM10-D	15-Mar-04	Field Electrode	0.500 U	
16PM10-D	17-Mar-04	Field Electrode	0.500 U	
16PM10-D	19-Mar-04	Field Electrode	0.500 U	
16PM10-D	24-Mar-04	Laboratory		6.00 U
16PM10-D	24-Mar-04	Field Electrode	0.500 U	
16PM10-D	30-Sep-04	Laboratory		**5.79**
16PM10-D	26-Jan-05	Laboratory		**3.46**
16PM10-S	27-Jun-03	Laboratory		**2.81**
16PM10-S	15-Feb-04	Field Electrode	0.500 U	
16PM10-S	16-Feb-04	Field Electrode	0.500 U	
16PM10-S	17-Feb-04	Field Electrode	0.500 U	
16PM10-S	18-Feb-04	Laboratory	**2.9**	
16PM10-S	18-Feb-04	Field Electrode	0.500 U	
16PM10-S	19-Feb-04	Field Electrode	0.500 U	
16PM10-S	20-Feb-04	Field Electrode	**8.9**	
16PM10-S	22-Feb-04	Laboratory	**99**	
16PM10-S	22-Feb-04	Field Electrode	**132**	
16PM10-S	24-Feb-04	Field Electrode	**99.6**	
16PM10-S	24-Feb-04	Field Electrode	**86.8**	
16PM10-S	25-Feb-04	Laboratory	**93**	
16PM10-S	25-Feb-04	Field Electrode	**119**	
16PM10-S	26-Feb-04	Field Electrode	**99.9**	
16PM10-S	27-Feb-04	Field Electrode	**112**	
16PM10-S	28-Feb-04	Field Electrode	**78.2**	
16PM10-S	1-Mar-04	Field Electrode	**82.7**	
16PM10-S	2-Mar-04	Field Electrode	**59.5**	
16PM10-S	3-Mar-04	Laboratory	**29**	
16PM10-S	3-Mar-04	Field Electrode	**35.2**	
16PM10-S	5-Mar-04	Field Electrode	**53.3**	
16PM10-S	8-Mar-04	Laboratory	**46**	
16PM10-S	8-Mar-04	Field Electrode	**50.1**	
16PM10-S	10-Mar-04	Field Electrode	**55.7**	
16PM10-S	12-Mar-04	Field Electrode	**78**	
16PM10-S	15-Mar-04	Field Electrode	**77.3**	
16PM10-S	17-Mar-04	Field Electrode	**75.4**	
16PM10-S	19-Mar-04	Field Electrode	**55**	
16PM10-S	24-Mar-04	Laboratory		**11.7**
16PM10-S	24-Mar-04	Field Electrode	**22.3**	
16PM10-S	30-Sep-04	Laboratory		**4.66**
16PM10-S	26-Jan-05	Laboratory		**3.04**
16PM11	27-Jun-03	Laboratory		**2.72**
16PM11	19-Feb-04	Field Electrode		0.500 U

TABLE H-1: RESULTS OF TRACER TEST (Winter 2004) ANIONS ANALYSIS.
Site 16 Landfill, LHAAP, Karnack, Texas

			Concentration (mg/L)	
Location	Date Sampled	Analysis	Iodide	Bromide
16EW13	06-Apr-04	Field Electrode		**53.3**
16EW14	26-Jun-03	Laboratory		**3.05**
16EW14	25-Mar-04	Field Electrode	0.500 U	
16EW14	25-Mar-04	Field Electrode		0.500 U
16EW14	25-Mar-04	Field Electrode	0.500 U	
16EW14	25-Mar-04	Field Electrode		0.500 U
16EW14	6-Apr-04	Field Electrode	**11.1**	
16EW14	06-Apr-04	Field Electrode		**44.4**
16EW14B	10-Feb-04	Field Electrode	0.500 U	
16EW14B	10-Feb-04	Field Electrode		0.500 U
16EW14B	10-Feb-04	Field Electrode	0.500 U	
16EW14B	10-Feb-04	Field Electrode		**4**
16EW14B	11-Feb-04	Field Electrode		**2**
16EW14B	11-Feb-04	Field Electrode	0.500 U	
16EW14B	11-Feb-04	Laboratory	**393**	
16EW14B	11-Feb-04	Field Electrode	**399**	
16EW14B	11-Feb-04	Field Electrode		**376**
16EW14B	11-Feb-04	Laboratory		**390**
16EW14B	12-Feb-04	Field Electrode		**436**
16EW14B	12-Feb-04	Field Electrode	**413**	
16EW14B	12-Feb-04	Field Electrode		**408**
16EW14B	12-Feb-04	Laboratory		**406**
16EW14B	12-Feb-04	Laboratory	**399**	
16EW14B	12-Feb-04	Field Electrode	**529**	
16EW14B	13-Feb-04	Field Electrode		**558**
16EW14B	13-Feb-04	Field Electrode	**657**	
16EW14B	13-Feb-04	Field Electrode	**548**	
16EW14B	13-Feb-04	Field Electrode		**523**
16EW14B	14-Feb-04	Field Electrode		**545**
16EW14B	14-Feb-04	Field Electrode	**525**	
16EW14B	14-Feb-04	Field Electrode	**492**	
16EW14B	14-Feb-04	Field Electrode		**396**
16EW14B	15-Feb-04	Field Electrode		**489**
16EW14B	15-Feb-04	Field Electrode	**477**	
16EW14B	15-Feb-04	Field Electrode		**505**
16EW14B	15-Feb-04	Laboratory		**460**
16EW14B	15-Feb-04	Field Electrode	**434**	
16EW14B	15-Feb-04	Laboratory	**455**	
16EW14B	16-Feb-04	Laboratory	**326**	
16EW14B	16-Feb-04	Field Electrode	**337**	
16EW14B	16-Feb-04	Field Electrode		**329**
16EW14B	16-Feb-04	Laboratory		**319**
16EW14B	16-Feb-04	Field Electrode	**545**	
16EW14B	16-Feb-04	Field Electrode		**517**
16EW14B	16-Feb-04	Field Electrode		**576**
16EW14B	16-Feb-04	Field Electrode	**542**	
16EW14B	17-Feb-04	Field Electrode	**445**	
16EW14B	17-Feb-04	Field Electrode		**433**
16EW14B	17-Feb-04	Field Electrode	**476**	
16EW14B	17-Feb-04	Field Electrode		**474**
16EW14B	17-Feb-04	Field Electrode	0.500 U	
16EW14B	18-Feb-04	Field Electrode	0.500 U	
16EW14B	18-Feb-04	Field Electrode		0.500 U

			Concentration (mg/L)	
Location	Date Sampled	Analysis	Iodide	Bromide
16PM11	20-Feb-04	Field Electrode		0.500 U
16PM11	22-Feb-04	Field Electrode		0.500 U
16PM11	23-Feb-04	Field Electrode		0.500 U
16PM11	24-Feb-04	Field Electrode		0.500 U
16PM11	25-Feb-04	Field Electrode		0.500 U
16PM11	26-Feb-04	Field Electrode		0.500 U
16PM11	27-Feb-04	Field Electrode		0.500 U
16PM11	28-Feb-04	Field Electrode		0.500 U
16PM11	01-Mar-04	Field Electrode		0.500 U
16PM11	02-Mar-04	Field Electrode		0.500 U
16PM11	03-Mar-04	Field Electrode		0.500 U
16PM11	05-Mar-04	Field Electrode		0.500 U
16PM11	08-Mar-04	Field Electrode		0.500 U
16PM11	10-Mar-04	Field Electrode	0.500 U	
16PM11	10-Mar-04	Field Electrode		0.500 U
16PM11	12-Mar-04	Field Electrode	0.500 U	
16PM11	12-Mar-04	Field Electrode		0.500 U
16PM11	15-Mar-04	Field Electrode	0.500 U	
16PM11	15-Mar-04	Field Electrode		**3.2**
16PM11	17-Mar-04	Field Electrode	0.500 U	
16PM11	17-Mar-04	Field Electrode		**2.5**
16PM11	19-Mar-04	Field Electrode	0.500 U	
16PM11	19-Mar-04	Field Electrode		**6.2**
16PM11	23-Mar-04	Laboratory		**5.88**
16PM11	24-Mar-04	Field Electrode	0.500 U	
16PM11	24-Mar-04	Field Electrode		0.500 U
16PM11	30-Sep-04	Laboratory		**3.51**
16PM11	26-Jan-05	Laboratory		**3.03**
16PM12	26-Jun-03	Laboratory		**0.73**
16PM12	05-Mar-04	Field Electrode		0.500 U
16PM12	8-Mar-04	Field Electrode	0.500 U	
16PM12	10-Mar-04	Field Electrode		0.500 U
16PM12	12-Mar-04	Field Electrode		0.500 U
16PM12	15-Mar-04	Field Electrode		0.500 U
16PM12	17-Mar-04	Field Electrode		0.500 U
16PM12	19-Mar-04	Field Electrode		0.500 U
16PM12	24-Mar-04	Laboratory		6.00 U
16PM12	24-Mar-04	Field Electrode		0.500 U
16PM12	06-Apr-04	Field Electrode		0.500 U
16PM12	29-Sep-04	Laboratory		**5.11**
16PM12	26-Jan-05	Laboratory		**4.65**
16PM13-D	27-Jun-03	Laboratory		**8.61**
16PM13-D	5-Mar-04	Field Electrode	0.500 U	
16PM13-D	8-Mar-04	Field Electrode	0.500 U	
16PM13-D	10-Mar-04	Field Electrode	0.500 U	
16PM13-D	12-Mar-04	Field Electrode	0.500 U	
16PM13-D	15-Mar-04	Field Electrode	0.500 U	
16PM13-D	17-Mar-04	Field Electrode	0.500 U	
16PM13-D	19-Mar-04	Field Electrode	0.500 U	
16PM13-D	23-Mar-04	Laboratory		**8.19**
16PM13-D	24-Mar-04	Field Electrode	0.500 U	
16PM13-D	30-Sep-04	Laboratory		**4.11**
16PM13-D	26-Jan-05	Laboratory		**8.97**

TABLE H-1: RESULTS OF TRACER TEST (Winter 2004) ANIONS ANALYSIS.
Site 16 Landfill, LHAAP, Karnack, Texas

			Concentration (mg/L)	
Location	Date Sampled	Analysis	Iodide	Bromide
16EW14B	18-Feb-04	Field Electrode	0.500 U	
16EW14B	18-Feb-04	Laboratory	2.50 U	
16EW14B	18-Feb-04	Field Electrode		0.500 U
16EW14B	18-Feb-04	Laboratory		0.140 U
16EW14B	19-Feb-04	Field Electrode	0.500 U	
16EW14B	19-Feb-04	Field Electrode		0.500 U
16EW14B	20-Feb-04	Field Electrode	0.500 U	
16EW14B	20-Feb-04	Field Electrode		0.500 U
16EW14B	22-Feb-04	Field Electrode	0.500 U	
16EW14B	22-Feb-04	Field Electrode		0.500 U
16EW14B	23-Feb-04	Field Electrode	0.500 U	
16EW14B	23-Feb-04	Field Electrode		**1,000**
16EW14B	24-Feb-04	Field Electrode		0.500 U
16EW14B	24-Feb-04	Field Electrode	0.500 U	
16EW14B	25-Feb-04	Field Electrode		0.500 U
16EW14B	25-Feb-04	Field Electrode	0.500 U	
16EW14B	26-Feb-04	Field Electrode	0.500 U	
16EW14B	26-Feb-04	Field Electrode		0.500 U
16EW14B	27-Feb-04	Field Electrode	0.500 U	
16EW14B	27-Feb-04	Field Electrode		0.500 U
16EW14B	28-Feb-04	Field Electrode	0.500 U	
16EW14B	28-Feb-04	Field Electrode		0.500 U
16EW14B	1-Mar-04	Field Electrode	0.500 U	
16EW14B	01-Mar-04	Field Electrode		**21.6**
16EW14B	2-Mar-04	Field Electrode	0.500 U	
16EW14B	02-Mar-04	Field Electrode		**3.5**
16EW14B	03-Mar-04	Field Electrode		**4.9**
16EW14B	3-Mar-04	Field Electrode	0.500 U	
16EW14B	4-Mar-04	Field Electrode	0.500 U	
16EW14B	5-Mar-04	Field Electrode	0.500 U	
16EW14B	05-Mar-04	Field Electrode		**7.6**
16EW14B	6-Mar-04	Field Electrode	0.500 U	
16EW14B	06-Mar-04	Field Electrode		**14.9**
16EW14B	06-Mar-04	Laboratory		**9**
16EW14B	8-Mar-04	Field Electrode	0.500 U	
16EW14B	08-Mar-04	Field Electrode		**15**
16EW14B	9-Mar-04	Field Electrode	0.500 U	
16EW14B	09-Mar-04	Field Electrode		**17**
16EW14B	09-Mar-04	Laboratory		**13**
16EW14B	10-Mar-04	Field Electrode	0.500 U	
16EW14B	10-Mar-04	Field Electrode		**17.5**
16EW14B	12-Mar-04	Field Electrode	0.500 U	
16EW14B	12-Mar-04	Field Electrode		**21.2**
16EW14B	15-Mar-04	Field Electrode	0.500 U	
16EW14B	15-Mar-04	Field Electrode		**24.7**
16EW14B	17-Mar-04	Field Electrode	0.500 U	
16EW14B	17-Mar-04	Field Electrode		**20.5**
16EW14B	19-Mar-04	Field Electrode	0.500 U	
16EW14B	19-Mar-04	Field Electrode		**20**
16EW14B	24-Mar-04	Laboratory		**18.2**
16EW14B	24-Mar-04	Field Electrode		**18.5**
16EW14B	24-Mar-04	Field Electrode	0.500 U	
16EW14B	6-Apr-04	Field Electrode	**6**	

			Concentration (mg/L)	
Location	Date Sampled	Analysis	Iodide	Bromide
16PM13-S	27-Jun-03	Laboratory		**1.48**
16PM13-S	5-Mar-04	Field Electrode	0.500 U	
16PM13-S	8-Mar-04	Field Electrode	0.500 U	
16PM13-S	10-Mar-04	Field Electrode	0.500 U	
16PM13-S	12-Mar-04	Field Electrode	0.500 U	
16PM13-S	15-Mar-04	Field Electrode	0.500 U	
16PM13-S	17-Mar-04	Field Electrode	0.500 U	
16PM13-S	19-Mar-04	Field Electrode	0.500 U	
16PM13-S	23-Mar-04	Laboratory		**5.25**
16PM13-S	24-Mar-04	Field Electrode	0.500 U	
16PM13-S	30-Sep-04	Laboratory		**3.32**
16PM13-S	26-Jan-05	Laboratory		**3.24**
16PM14	27-Jun-03	Laboratory		**2.39**
16PM14	23-Mar-04	Laboratory		**6.01**
16PM14	30-Sep-04	Laboratory		**3.15**
16PM14	26-Jan-05	Laboratory		**8.08**
16WW16	30-Jun-03	Laboratory		**4.11**
IW1	10-Feb-04	Field Electrode		**2**
IW1	11-Feb-04	Field Electrode		0.500 U
IW1	11-Feb-04	Field Electrode		**2**
IW1	12-Feb-04	Field Electrode		0.500 U
IW1	12-Feb-04	Field Electrode		0.500 U
IW1	12-Feb-04	Laboratory		**2.1**
IW1	13-Feb-04	Field Electrode		0.500 U
IW1	13-Feb-04	Field Electrode		0.500 U
IW1	14-Feb-04	Field Electrode		0.500 U
IW1	14-Feb-04	Field Electrode		**4**
IW1	15-Feb-04	Field Electrode		**2**
IW1	15-Feb-04	Field Electrode		0.500 U
IW1	16-Feb-04	Field Electrode		0.500 U
IW1	16-Feb-04	Field Electrode		0.500 U
IW1	16-Feb-04	Laboratory		**1.8**
IW1	17-Feb-04	Field Electrode		**5**
IW1	18-Feb-04	Field Electrode		0.500 U
IW1	18-Feb-04	Field Electrode		**7**
IW1	19-Feb-04	Field Electrode		**2.9**
IW1	20-Feb-04	Field Electrode		**24.1**
IW1	20-Feb-04	Laboratory		**17**
IW1	22-Feb-04	Field Electrode		**21.1**
IW1	22-Feb-04	Laboratory		**21**
IW1	23-Feb-04	Field Electrode		**145**
IW1	23-Feb-04	Laboratory		**102**
IW1	25-Feb-04	Field Electrode		**159**
IW1	25-Feb-04	Laboratory		**149**
IW1	26-Feb-04	Field Electrode		**153**
IW1	27-Feb-04	Field Electrode		**135**
IW1	28-Feb-04	Field Electrode		**173**
IW1	28-Feb-04	Laboratory		**188**
IW1	01-Mar-04	Field Electrode		**138**
IW1	02-Mar-04	Field Electrode		**120**
IW1	03-Mar-04	Field Electrode		**81.1**
IW1	03-Mar-04	Laboratory		**81**
IW1	05-Mar-04	Field Electrode		**54.1**

TABLE H-1: RESULTS OF TRACER TEST (Winter 2004) ANIONS ANALYSIS.
Site 16 Landfill, LHAAP, Karnack, Texas

			Concentration (mg/L)	
Location	Date Sampled	Analysis	Iodide	Bromide
16EW14B	06-Apr-04	Field Electrode		**55.2**
16EW14B	29-Sep-04	Laboratory		**42.3**
16EW14B	26-Jan-05	Laboratory		**22.9**
16EW15	26-Jun-03	Laboratory		**9.67**
16PM01	26-Jun-03	Laboratory		**1.56**
16PM01	12-Feb-04	Field Electrode		0.500 U
16PM01	13-Feb-04	Field Electrode	0.500 U	
16PM01	13-Feb-04	Field Electrode		0.500 U
16PM01	14-Feb-04	Field Electrode	0.500 U	
16PM01	14-Feb-04	Field Electrode		0.500 U
16PM01	15-Feb-04	Field Electrode	**7**	
16PM01	15-Feb-04	Field Electrode		0.500 U
16PM01	16-Feb-04	Field Electrode	0.500 U	
16PM01	16-Feb-04	Field Electrode		0.500 U
16PM01	17-Feb-04	Field Electrode	0.500 U	
16PM01	17-Feb-04	Field Electrode		0.500 U
16PM01	18-Feb-04	Field Electrode	0.500 U	
16PM01	18-Feb-04	Field Electrode		0.500 U
16PM01	19-Feb-04	Field Electrode	0.500 U	
16PM01	19-Feb-04	Field Electrode		**3.2**
16PM01	20-Feb-04	Field Electrode	0.500 U	
16PM01	20-Feb-04	Field Electrode		0.500 U
16PM01	22-Feb-04	Field Electrode	0.500 U	
16PM01	22-Feb-04	Field Electrode		0.500 U
16PM01	23-Feb-04	Field Electrode	0.500 U	
16PM01	23-Feb-04	Field Electrode		**2.5**
16PM01	24-Feb-04	Field Electrode	0.500 U	
16PM01	24-Feb-04	Field Electrode		0.500 U
16PM01	25-Feb-04	Field Electrode	0.500 U	
16PM01	25-Feb-04	Field Electrode		0.500 U
16PM01	26-Feb-04	Field Electrode	0.500 U	
16PM01	26-Feb-04	Field Electrode		0.500 U
16PM01	27-Feb-04	Field Electrode	0.500 U	
16PM01	27-Feb-04	Field Electrode		0.500 U
16PM01	28-Feb-04	Field Electrode	0.500 U	
16PM01	28-Feb-04	Field Electrode		0.500 U
16PM01	1-Mar-04	Field Electrode	0.500 U	
16PM01	01-Mar-04	Field Electrode		0.500 U
16PM01	2-Mar-04	Field Electrode	0.500 U	
16PM01	02-Mar-04	Field Electrode		0.500 U
16PM01	3-Mar-04	Field Electrode	0.500 U	
16PM01	03-Mar-04	Field Electrode		0.500 U
16PM01	5-Mar-04	Field Electrode	0.500 U	
16PM01	05-Mar-04	Field Electrode		0.500 U
16PM01	8-Mar-04	Field Electrode	0.500 U	
16PM01	08-Mar-04	Field Electrode		0.500 U
16PM01	23-Mar-04	Laboratory		**0.89**
16PM01	30-Sep-04	Laboratory		**1.11**
16PM01	26-Jan-05	Laboratory		**1.21**
16PM02	26-Jun-03	Laboratory		**0.89**
16PM02	23-Mar-04	Laboratory		**2.34**
16PM02	30-Sep-04	Laboratory		**1.73**
16PM02	26-Jan-05	Laboratory		**1.97**

			Concentration (mg/L)	
Location	Date Sampled	Analysis	Iodide	Bromide
IW1	08-Mar-04	Field Electrode		**32**
IW1	08-Mar-04	Laboratory		**25**
IW2	12-Feb-04	Field Electrode		0.500 U
IW2	12-Feb-04	Field Electrode		0.500 U
IW2	13-Feb-04	Field Electrode		0.500 U
IW2	14-Feb-04	Field Electrode		0.500 U
IW2	15-Feb-04	Field Electrode		0.500 U
IW2	16-Feb-04	Field Electrode		0.500 U
IW2	17-Feb-04	Field Electrode		**4**
IW2	17-Feb-04	Laboratory		**1.6**
IW2	18-Feb-04	Field Electrode		0.500 U
IW2	18-Feb-04	Laboratory		**1**
IW2	19-Feb-04	Field Electrode		0.500 U
IW2	20-Feb-04	Field Electrode		0.500 U
IW2	22-Feb-04	Field Electrode		0.500 U
IW2	23-Feb-04	Field Electrode		0.500 U
IW2	24-Feb-04	Field Electrode		0.500 U
IW2	25-Feb-04	Field Electrode		0.500 U
IW2	26-Feb-04	Field Electrode		0.500 U
IW2	27-Feb-04	Field Electrode		0.500 U
IW2	28-Feb-04	Field Electrode		0.500 U
IW2	01-Mar-04	Field Electrode		0.500 U
IW2	02-Mar-04	Field Electrode		0.500 U
IW2	03-Mar-04	Field Electrode		0.500 U
IW2	04-Mar-04	Field Electrode		0.500 U
IW2	05-Mar-04	Field Electrode		**9.6**
IW2	05-Mar-04	Laboratory		**9.5**
IW2	06-Mar-04	Field Electrode		**12.8**
IW2	08-Mar-04	Field Electrode		**15.7**
IW2	09-Mar-04	Field Electrode		**17.6**
IW2	09-Mar-04	Laboratory		**22**
IW2	10-Mar-04	Field Electrode		**38.1**
IW2	12-Mar-04	Field Electrode		**30.9**
IW2	15-Mar-04	Field Electrode		**23.1**
IW2	15-Mar-04	Laboratory		**21**
IW2	17-Mar-04	Field Electrode		**23.5**
IW2	19-Mar-04	Field Electrode		**24.5**
IW2	24-Mar-04	Field Electrode		**22.7**
IW3	12-Feb-04	Field Electrode	0.500 U	
IW3	14-Feb-04	Field Electrode	0.500 U	
IW3	15-Feb-04	Field Electrode	**4**	
IW3	16-Feb-04	Field Electrode	0.500 U	
IW3	17-Feb-04	Field Electrode	0.500 U	
IW3	18-Feb-04	Field Electrode	0.500 U	
IW3	19-Feb-04	Field Electrode	0.500 U	
IW3	19-Feb-04	Field Electrode		0.500 U
IW3	20-Feb-04	Field Electrode	0.500 U	
IW3	20-Feb-04	Field Electrode		0.500 U
IW3	22-Feb-04	Field Electrode	0.500 U	
IW3	22-Feb-04	Field Electrode		0.500 U
IW3	23-Feb-04	Field Electrode	0.500 U	
IW3	24-Feb-04	Field Electrode	0.500 U	
IW3	25-Feb-04	Field Electrode	0.500 U	

TABLE H-1: RESULTS OF TRACER TEST (Winter 2004) ANIONS ANALYSIS.
Site 16 Landfill, LHAAP, Karnack, Texas

			Concentration (mg/L)	
Location	Date Sampled	Analysis	Iodide	Bromide
16PM03	30-Jun-03	Laboratory		**1.79**
16PM03	23-Mar-04	Laboratory		**5.35**
16PM03	30-Sep-04	Laboratory		**2.46**
16PM03	26-Jan-05	Laboratory		**2.75**
16PM04	27-Jun-03	Laboratory		0.600 U
16PM04	12-Feb-04	Field Electrode	0.500 U	
16PM04	13-Feb-04	Field Electrode	0.500 U	
16PM04	14-Feb-04	Field Electrode	0.500 U	
16PM04	15-Feb-04	Field Electrode	0.500 U	
16PM04	16-Feb-04	Field Electrode		-23.7
16PM04	16-Feb-04	Field Electrode	0.500 U	
16PM04	16-Feb-04	Field Electrode		**0.5**
16PM04	17-Feb-04	Field Electrode	0.500 U	
16PM04	18-Feb-04	Field Electrode		-35.8
16PM04	18-Feb-04	Field Electrode		**0.5**
16PM04	18-Feb-04	Field Electrode	0.500 U	
16PM04	18-Feb-04	Laboratory	2.50 U	
16PM04	19-Feb-04	Field Electrode	0.500 U	
16PM04	20-Feb-04	Field Electrode	0.500 U	
16PM04	20-Feb-04	Field Electrode		0.500 U
16PM04	22-Feb-04	Field Electrode		-30.2
16PM04	22-Feb-04	Field Electrode	0.500 U	
16PM04	22-Feb-04	Field Electrode		**0.5**
16PM04	22-Feb-04	Field Electrode		-11.7
16PM04	23-Feb-04	Field Electrode		**16.3**
16PM04	23-Feb-04	Field Electrode	0.500 U	
16PM04	23-Feb-04	Field Electrode		**17**
16PM04	24-Feb-04	Field Electrode	**9.7**	
16PM04	25-Feb-04	Field Electrode		**24.2**
16PM04	25-Feb-04	Laboratory		**1.35**
16PM04	25-Feb-04	Field Electrode	**19.4**	
16PM04	25-Feb-04	Laboratory	2.50 U	
16PM04	25-Feb-04	Field Electrode		**25.9**
16PM04	26-Feb-04	Field Electrode	**17.7**	
16PM04	27-Feb-04	Field Electrode	**21.5**	
16PM04	28-Feb-04	Field Electrode		**61.4**
16PM04	28-Feb-04	Laboratory	**30**	
16PM04	28-Feb-04	Field Electrode	**44**	
16PM04	28-Feb-04	Field Electrode		**71.7**
16PM04	1-Mar-04	Field Electrode	**42.1**	
16PM04	2-Mar-04	Field Electrode	**46.5**	
16PM04	3-Mar-04	Field Electrode	**47.3**	
16PM04	04-Mar-04	Field Electrode		**142**
16PM04	04-Mar-04	Laboratory		**1.27**
16PM04	4-Mar-04	Laboratory	**37**	
16PM04	4-Mar-04	Field Electrode	**49.7**	
16PM04	04-Mar-04	Field Electrode		**163**
16PM04	5-Mar-04	Field Electrode	**54.8**	
16PM04	6-Mar-04	Field Electrode	**64.9**	
16PM04	06-Mar-04	Field Electrode		**138**
16PM04	8-Mar-04	Field Electrode	**40.9**	
16PM04	8-Mar-04	Laboratory	**44**	
16PM04	9-Mar-04	Field Electrode	**51.6**	

			Concentration (mg/L)	
Location	Date Sampled	Analysis	Iodide	Bromide
IW3	26-Feb-04	Field Electrode	0.500 U	
IW3	27-Feb-04	Field Electrode	**3.6**	
IW3	28-Feb-04	Field Electrode	0.500 U	
IW3	28-Feb-04	Field Electrode		0.500 U
IW3	1-Mar-04	Field Electrode	**9.8**	
IW3	01-Mar-04	Field Electrode		**17.6**
IW3	01-Mar-04	Laboratory		**0.884**
IW3	2-Mar-04	Field Electrode	**15.2**	
IW3	02-Mar-04	Field Electrode		**27.3**
IW3	3-Mar-04	Field Electrode	**18.5**	
IW3	03-Mar-04	Field Electrode		**24.8**
IW3	4-Mar-04	Laboratory	**12**	
IW3	4-Mar-04	Field Electrode	**17**	
IW3	04-Mar-04	Field Electrode		**30**
IW3	04-Mar-04	Laboratory		**1.07**
IW3	5-Mar-04	Field Electrode	**44.9**	
IW3	6-Mar-04	Field Electrode	**52.6**	
IW3	8-Mar-04	Field Electrode	**52.8**	
IW3	9-Mar-04	Field Electrode	**51.3**	
IW3	10-Mar-04	Field Electrode	**50.6**	
IW3	12-Mar-04	Field Electrode	**69.9**	
IW3	15-Mar-04	Field Electrode	**69.3**	
IW3	17-Mar-04	Field Electrode	**49.5**	
IW3	19-Mar-04	Field Electrode	**49.1**	
IW3	24-Mar-04	Field Electrode	**40.2**	
IW4	10-Feb-04	Field Electrode	0.500 U	
IW4	11-Feb-04	Field Electrode	0.500 U	
IW4	11-Feb-04	Field Electrode	0.500 U	
IW4	12-Feb-04	Field Electrode	**1**	
IW4	12-Feb-04	Field Electrode	0.500 U	
IW4	12-Feb-04	Laboratory	2.50 U	
IW4	13-Feb-04	Field Electrode	0.500 U	
IW4	13-Feb-04	Field Electrode	0.500 U	
IW4	14-Feb-04	Field Electrode	0.500 U	
IW4	14-Feb-04	Field Electrode	**3**	
IW4	15-Feb-04	Field Electrode	**6**	
IW4	15-Feb-04	Field Electrode	0.500 U	
IW4	15-Feb-04	Laboratory	2.50 U	
IW4	16-Feb-04	Field Electrode	0.500 U	
IW4	16-Feb-04	Field Electrode	0.500 U	
IW4	16-Feb-04	Laboratory	2.50 U	
IW4	17-Feb-04	Field Electrode	0.500 U	
IW4	17-Feb-04	Field Electrode	0.500 U	
IW4	18-Feb-04	Field Electrode	0.500 U	
IW4	18-Feb-04	Field Electrode	0.500 U	
IW4	18-Feb-04	Laboratory	2.50 U	
IW4	19-Feb-04	Field Electrode	0.500 U	
IW4	19-Feb-04	Field Electrode		0.500 U
IW4	20-Feb-04	Field Electrode	0.500 U	
IW4	20-Feb-04	Laboratory	2.50 U	
IW4	20-Feb-04	Field Electrode		0.500 U
IW4	22-Feb-04	Field Electrode	**8.6**	
IW4	22-Feb-04	Laboratory	2.50 U	

TABLE H-1: RESULTS OF TRACER TEST (Winter 2004) ANIONS ANALYSIS.
Site 16 Landfill, LHAAP, Karnack, Texas

			Concentration (mg/L)	
Location	Date Sampled	Analysis	Iodide	Bromide
16PM04	09-Mar-04	Field Electrode		**126**
16PM04	10-Mar-04	Field Electrode	**47.1**	
16PM04	12-Mar-04	Field Electrode	**61.8**	
16PM04	15-Mar-04	Field Electrode	**65.3**	
16PM04	15-Mar-04	Field Electrode		**149**
16PM04	17-Mar-04	Field Electrode	**66**	
16PM04	19-Mar-04	Field Electrode	**66**	
16PM04	23-Mar-04	Laboratory		**4.4**
16PM04	24-Mar-04	Field Electrode		**162**
16PM04	24-Mar-04	Laboratory		**1.81**
16PM04	24-Mar-04	Field Electrode	**59.6**	
16PM04	24-Mar-04	Field Electrode		**184**
16PM04	25-Mar-04	Field Electrode		**157**
16PM04	6-Apr-04	Field Electrode	**43.2**	
16PM04	06-Apr-04	Field Electrode		**221**
16PM04	30-Sep-04	Laboratory		**2.6**
16PM04	26-Jan-05	Laboratory		**3.54**
16PM05	26-Jun-03	Laboratory		**0.87**
16PM05	10-Feb-04	Field Electrode		**12**
16PM05	11-Feb-04	Field Electrode		**11**
16PM05	11-Feb-04	Field Electrode		**13**
16PM05	12-Feb-04	Field Electrode		**14**
16PM05	12-Feb-04	Field Electrode		**15**
16PM05	12-Feb-04	Laboratory		**4.1**
16PM05	13-Feb-04	Field Electrode		**14**
16PM05	13-Feb-04	Field Electrode		**14**
16PM05	14-Feb-04	Field Electrode		**13**
16PM05	14-Feb-04	Field Electrode		**12**
16PM05	15-Feb-04	Field Electrode		**12**
16PM05	15-Feb-04	Field Electrode		**5**
16PM05	16-Feb-04	Field Electrode		**11**
16PM05	16-Feb-04	Field Electrode		**11**
16PM05	16-Feb-04	Laboratory		**4.3**
16PM05	17-Feb-04	Field Electrode		**19**
16PM05	18-Feb-04	Field Electrode		**18**
16PM05	18-Feb-04	Field Electrode		**13**
16PM05	18-Feb-04	Laboratory		**7**
16PM05	19-Feb-04	Field Electrode		**18.6**
16PM05	20-Feb-04	Field Electrode		**34.2**
16PM05	20-Feb-04	Laboratory		**18**
16PM05	22-Feb-04	Field Electrode		**50.1**
16PM05	22-Feb-04	Laboratory		**44**
16PM05	23-Feb-04	Field Electrode		**107**
16PM05	24-Feb-04	Field Electrode		**136**
16PM05	25-Feb-04	Field Electrode		**174**
16PM05	25-Feb-04	Laboratory		**151**
16PM05	26-Feb-04	Field Electrode		**222**
16PM05	27-Feb-04	Field Electrode		**180**
16PM05	28-Feb-04	Field Electrode		**196**
16PM05	28-Feb-04	Laboratory		**211**
16PM05	01-Mar-04	Field Electrode		**229**
16PM05	02-Mar-04	Field Electrode		**212**
16PM05	03-Mar-04	Field Electrode		**199**

			Concentration (mg/L)	
Location	Date Sampled	Analysis	Iodide	Bromide
IW4	22-Feb-04	Field Electrode		0.500 U
IW4	23-Feb-04	Field Electrode	**9.7**	
IW4	23-Feb-04	Field Electrode		0.500 U
IW4	24-Feb-04	Field Electrode	**8**	
IW4	24-Feb-04	Field Electrode		0.500 U
IW4	25-Feb-04	Field Electrode	**18.5**	
IW4	25-Feb-04	Laboratory	2.50 U	
IW4	25-Feb-04	Field Electrode		**27.2**
IW4	25-Feb-04	Laboratory		**1.27**
IW4	26-Feb-04	Field Electrode	**21.3**	
IW4	26-Feb-04	Field Electrode		**34.9**
IW4	27-Feb-04	Field Electrode	**19.1**	
IW4	27-Feb-04	Field Electrode		**33.4**
IW4	28-Feb-04	Laboratory	**19**	
IW4	28-Feb-04	Field Electrode	**32.3**	
IW4	28-Feb-04	Field Electrode		**35.6**
IW4	1-Mar-04	Field Electrode	**25.5**	
IW4	01-Mar-04	Field Electrode		**48.5**
IW4	01-Mar-04	Laboratory		**1.12**
IW4	2-Mar-04	Field Electrode	**26.2**	
IW4	3-Mar-04	Laboratory	**19**	
IW4	3-Mar-04	Field Electrode	**22.3**	
IW4	5-Mar-04	Field Electrode	**37.2**	
IW4	8-Mar-04	Laboratory	**25**	
IW4	8-Mar-04	Field Electrode	**28.5**	
IW4	10-Mar-04	Field Electrode	**34**	
IW4	12-Mar-04	Field Electrode	**43.6**	
IW4	15-Mar-04	Field Electrode	**42.5**	
IW4	17-Mar-04	Field Electrode	**44.6**	
IW4	19-Mar-04	Field Electrode	**48.7**	
IW4	24-Mar-04	Field Electrode	**44.9**	
IW5	10-Feb-04	Field Electrode	0.500 U	
IW5	11-Feb-04	Field Electrode	0.500 U	
IW5	11-Feb-04	Field Electrode	**1**	
IW5	12-Feb-04	Field Electrode	**4**	
IW5	12-Feb-04	Field Electrode	0.500 U	
IW5	12-Feb-04	Laboratory	2.50 U	
IW5	13-Feb-04	Field Electrode	0.500 U	
IW5	13-Feb-04	Field Electrode	0.500 U	
IW5	14-Feb-04	Field Electrode	0.500 U	
IW5	14-Feb-04	Field Electrode	**7**	
IW5	15-Feb-04	Field Electrode	**11**	
IW5	15-Feb-04	Field Electrode	**4**	
IW5	15-Feb-04	Laboratory	2.50 U	
IW5	16-Feb-04	Field Electrode	**19**	
IW5	16-Feb-04	Laboratory	**16**	
IW5	16-Feb-04	Field Electrode	**20**	
IW5	17-Feb-04	Field Electrode	**56**	
IW5	17-Feb-04	Field Electrode	**80**	
IW5	18-Feb-04	Field Electrode	**106**	
IW5	18-Feb-04	Laboratory	**43**	
IW5	18-Feb-04	Field Electrode	**91.2**	
IW5	19-Feb-04	Field Electrode	**125**	

TABLE H-1: RESULTS OF TRACER TEST (Winter 2004) ANIONS ANALYSIS.
Site 16 Landfill, LHAAP, Karnack, Texas

			Concentration (mg/L)	
Location	Date Sampled	Analysis	Iodide	Bromide
16PM05	03-Mar-04	Laboratory		**183**
16PM05	05-Mar-04	Field Electrode		**138**
16PM05	08-Mar-04	Field Electrode		**92.4**
16PM05	08-Mar-04	Laboratory		**78**
16PM05	10-Mar-04	Field Electrode		**68.5**
16PM05	12-Mar-04	Field Electrode		**58.7**
16PM05	15-Mar-04	Field Electrode		**52.8**
16PM05	17-Mar-04	Field Electrode		**40.7**
16PM05	19-Mar-04	Field Electrode		**44.4**
16PM05	24-Mar-04	Laboratory		**31.4**
16PM05	24-Mar-04	Field Electrode		**31.1**
16PM05	29-Sep-04	Laboratory		**12.8**
16PM05	26-Jan-05	Laboratory		**17.1**
16PM06	27-Jun-03	Laboratory		0.600 U
16PM06	10-Feb-04	Field Electrode	0.500 U	
16PM06	11-Feb-04	Field Electrode	0.500 U	
16PM06	11-Feb-04	Field Electrode	0.500 U	
16PM06	12-Feb-04	Field Electrode	0.500 U	
16PM06	12-Feb-04	Field Electrode	0.500 U	
16PM06	12-Feb-04	Laboratory	2.50 U	
16PM06	13-Feb-04	Field Electrode	0.500 U	
16PM06	13-Feb-04	Field Electrode	0.500 U	
16PM06	14-Feb-04	Field Electrode	**7**	
16PM06	14-Feb-04	Field Electrode	**18**	
16PM06	15-Feb-04	Field Electrode	**92**	
16PM06	15-Feb-04	Laboratory	**70**	
16PM06	15-Feb-04	Field Electrode	**103**	
16PM06	16-Feb-04	Field Electrode	**135**	
16PM06	16-Feb-04	Laboratory	**169**	
16PM06	16-Feb-04	Field Electrode	**219**	
16PM06	17-Feb-04	Field Electrode	**250**	
16PM06	17-Feb-04	Field Electrode	**253**	
16PM06	18-Feb-04	Field Electrode	**260**	
16PM06	18-Feb-04	Field Electrode	**276**	
16PM06	19-Feb-04	Field Electrode	**268**	
16PM06	20-Feb-04	Field Electrode	**248**	
16PM06	22-Feb-04	Field Electrode	**153**	
16PM06	23-Feb-04	Field Electrode	**188**	
16PM06	24-Feb-04	Field Electrode	**174**	
16PM06	25-Feb-04	Field Electrode	**136**	
16PM06	26-Feb-04	Field Electrode	**149**	
16PM06	27-Feb-04	Field Electrode	**110**	
16PM06	28-Feb-04	Laboratory	**72**	
16PM06	28-Feb-04	Field Electrode	**101**	
16PM06	1-Mar-04	Field Electrode	**68.2**	
16PM06	2-Mar-04	Field Electrode	**25.3**	
16PM06	3-Mar-04	Field Electrode	**37.7**	
16PM06	5-Mar-04	Field Electrode	**27.2**	
16PM06	8-Mar-04	Field Electrode	**23.4**	
16PM06	23-Mar-04	Laboratory		**20.1**
16PM06	30-Sep-04	Laboratory		**7.41**
16PM06	26-Jan-05	Laboratory		**3.9**
16PM07-D	27-Jun-03	Laboratory		**7.35**

			Concentration (mg/L)	
Location	Date Sampled	Analysis	Iodide	Bromide
IW5	20-Feb-04	Laboratory	**90**	
IW5	20-Feb-04	Field Electrode	**126**	
IW5	22-Feb-04	Field Electrode	**136**	
IW5	22-Feb-04	Laboratory	**139**	
IW5	23-Feb-04	Field Electrode	**184**	
IW5	24-Feb-04	Field Electrode	**179**	
IW5	25-Feb-04	Laboratory	**119**	
IW5	25-Feb-04	Field Electrode	**149**	
IW5	26-Feb-04	Field Electrode	**165**	
IW5	27-Feb-04	Field Electrode	**169**	
IW5	28-Feb-04	Field Electrode	**122**	
IW5	1-Mar-04	Field Electrode	**148**	
IW5	2-Mar-04	Field Electrode	**135**	
IW5	3-Mar-04	Field Electrode	**145**	
IW5	5-Mar-04	Field Electrode	**118**	
IW5	8-Mar-04	Field Electrode	**85.6**	
IW5	8-Mar-04	Laboratory	**89**	
IW5	10-Mar-04	Field Electrode	**75.9**	
IW5	12-Mar-04	Field Electrode	**75.7**	
IW5	15-Mar-04	Field Electrode	**51.7**	
IW5	17-Mar-04	Field Electrode	**37.7**	
IW5	19-Mar-04	Field Electrode	**39.1**	
IW5	24-Mar-04	Field Electrode	**21.9**	
IW6	12-Feb-04	Field Electrode	0.500 U	
IW6	14-Feb-04	Field Electrode	0.500 U	
IW6	15-Feb-04	Field Electrode	0.500 U	
IW6	16-Feb-04	Field Electrode	0.500 U	
IW6	17-Feb-04	Field Electrode	0.500 U	
IW6	18-Feb-04	Field Electrode	0.500 U	
IW6	19-Feb-04	Field Electrode	0.500 U	
IW6	20-Feb-04	Field Electrode	0.500 U	
IW6	22-Feb-04	Field Electrode	0.500 U	
IW6	23-Feb-04	Field Electrode	0.500 U	
IW6	24-Feb-04	Field Electrode	0.500 U	
IW6	25-Feb-04	Field Electrode	0.500 U	
IW6	26-Feb-04	Field Electrode	0.500 U	
IW6	27-Feb-04	Field Electrode	**4.1**	
IW6	28-Feb-04	Field Electrode	**5.9**	
IW6	28-Feb-04	Laboratory	2.50 U	
IW6	1-Mar-04	Field Electrode	**9.5**	
IW6	2-Mar-04	Field Electrode	**13.8**	
IW6	3-Mar-04	Field Electrode	**14.1**	
IW6	4-Mar-04	Laboratory	**5**	
IW6	4-Mar-04	Field Electrode	**13.1**	
IW6	5-Mar-04	Laboratory	**7.4**	
IW6	5-Mar-04	Field Electrode	**27**	
IW6	6-Mar-04	Field Electrode	**26.5**	
IW6	8-Mar-04	Field Electrode	**21.4**	
IW6	9-Mar-04	Field Electrode	**13.9**	
IW6	9-Mar-04	Laboratory	**16**	
IW6	10-Mar-04	Field Electrode	**20**	
IW6	12-Mar-04	Field Electrode	**27.2**	
IW6	15-Mar-04	Field Electrode	**37**	

TABLE H-1: RESULTS OF TRACER TEST (Winter 2004) ANIONS ANALYSIS.
Site 16 Landfill, LHAAP, Karnack, Texas

			Concentration (mg/L)	
Location	Date Sampled	Analysis	Iodide	Bromide
16PM07-D	19-Feb-04	Field Electrode	0.500 U	
16PM07-D	20-Feb-04	Field Electrode	0.500 U	
16PM07-D	22-Feb-04	Field Electrode	0.500 U	
16PM07-D	23-Feb-04	Field Electrode	0.500 U	
16PM07-D	24-Feb-04	Field Electrode	0.500 U	
16PM07-D	25-Feb-04	Field Electrode	0.500 U	
16PM07-D	26-Feb-04	Field Electrode	0.500 U	
16PM07-D	27-Feb-04	Field Electrode	0.500 U	
16PM07-D	28-Feb-04	Field Electrode	0.500 U	
16PM07-D	1-Mar-04	Field Electrode	0.500 U	
16PM07-D	2-Mar-04	Field Electrode	0.500 U	
16PM07-D	3-Mar-04	Field Electrode	0.500 U	
16PM07-D	4-Mar-04	Field Electrode	0.500 U	
16PM07-D	5-Mar-04	Field Electrode	0.500 U	
16PM07-D	6-Mar-04	Field Electrode	0.500 U	
16PM07-D	8-Mar-04	Field Electrode	0.500 U	
16PM07-D	9-Mar-04	Field Electrode	0.500 U	
16PM07-D	10-Mar-04	Field Electrode	0.500 U	
16PM07-D	12-Mar-04	Field Electrode	0.500 U	
16PM07-D	15-Mar-04	Field Electrode	0.500 U	
16PM07-D	17-Mar-04	Field Electrode	0.500 U	
16PM07-D	19-Mar-04	Field Electrode	0.500 U	
16PM07-D	23-Mar-04	Laboratory		**6.19**
16PM07-D	24-Mar-04	Field Electrode	0.500 U	
16PM07-D	6-Apr-04	Field Electrode	0.500 U	
16PM07-D	30-Sep-04	Laboratory		**3.47**
16PM07-D	26-Jan-05	Laboratory		**6.24**
16PM07-S	27-Jun-03	Laboratory		**5.64**
16PM07-S	19-Feb-04	Field Electrode	0.500 U	
16PM07-S	20-Feb-04	Field Electrode	0.500 U	
16PM07-S	22-Feb-04	Field Electrode	0.500 U	
16PM07-S	23-Feb-04	Field Electrode	0.500 U	
16PM07-S	24-Feb-04	Field Electrode	0.500 U	
16PM07-S	25-Feb-04	Field Electrode	0.500 U	
16PM07-S	26-Feb-04	Field Electrode	0.500 U	
16PM07-S	27-Feb-04	Field Electrode	0.500 U	
16PM07-S	28-Feb-04	Field Electrode	0.500 U	
16PM07-S	1-Mar-04	Field Electrode	0.500 U	
16PM07-S	2-Mar-04	Field Electrode	0.500 U	
16PM07-S	3-Mar-04	Field Electrode	0.500 U	
16PM07-S	4-Mar-04	Field Electrode	0.500 U	
16PM07-S	5-Mar-04	Field Electrode	0.500 U	
16PM07-S	6-Mar-04	Field Electrode	0.500 U	
16PM07-S	8-Mar-04	Laboratory	**4.9**	
16PM07-S	8-Mar-04	Field Electrode	**19.5**	
16PM07-S	9-Mar-04	Laboratory	**5.1**	
16PM07-S	9-Mar-04	Field Electrode	**8.9**	
16PM07-S	10-Mar-04	Field Electrode	**11.2**	
16PM07-S	12-Mar-04	Field Electrode	**14.1**	
16PM07-S	15-Mar-04	Field Electrode	**16.2**	
16PM07-S	17-Mar-04	Field Electrode	**35**	
16PM07-S	19-Mar-04	Field Electrode	**30.7**	
16PM07-S	23-Mar-04	Laboratory		**3.69**

			Concentration (mg/L)	
Location	Date Sampled	Analysis	Iodide	Bromide
IW6	17-Mar-04	Field Electrode	**38.3**	
IW6	19-Mar-04	Field Electrode	**45.3**	
IW6	24-Mar-04	Field Electrode	**43.2**	
IW7	12-Feb-04	Field Electrode		0.500 U
IW7	12-Feb-04	Field Electrode		0.500 U
IW7	13-Feb-04	Field Electrode		**13**
IW7	14-Feb-04	Field Electrode		**4**
IW7	15-Feb-04	Field Electrode		**8**
IW7	16-Feb-04	Field Electrode		**5**
IW7	17-Feb-04	Field Electrode		**15**
IW7	18-Feb-04	Field Electrode		**17**
IW7	18-Feb-04	Field Electrode		**16**
IW7	18-Feb-04	Laboratory		**5.6**
IW7	19-Feb-04	Field Electrode		**21.6**
IW7	20-Feb-04	Field Electrode		**39.6**
IW7	22-Feb-04	Field Electrode		**47.4**
IW7	22-Feb-04	Laboratory		**36**
IW7	23-Feb-04	Field Electrode		**90.4**
IW7	24-Feb-04	Field Electrode		**58.6**
IW7	25-Feb-04	Field Electrode		**81.1**
IW7	25-Feb-04	Laboratory		**71**
IW7	26-Feb-04	Field Electrode		**76**
IW7	27-Feb-04	Field Electrode		**64.4**
IW7	28-Feb-04	Field Electrode		**82**
IW7	01-Mar-04	Field Electrode		**85.7**
IW7	02-Mar-04	Field Electrode		**77.1**
IW7	03-Mar-04	Field Electrode		**72**
IW7	03-Mar-04	Laboratory		**56**
IW7	05-Mar-04	Field Electrode		**61.9**
IW7	05-Mar-04	Laboratory		**44**
IW7	08-Mar-04	Field Electrode		**58.3**
IW7	08-Mar-04	Laboratory		**37**
IW7	10-Mar-04	Field Electrode		**66**
IW7	12-Mar-04	Field Electrode		**77**
IW7	15-Mar-04	Field Electrode		**59.2**
IW7	15-Mar-04	Laboratory		**41**
IW7	17-Mar-04	Field Electrode		**84.9**
IW7	19-Mar-04	Field Electrode		**68.5**
IW7	24-Mar-04	Field Electrode		**44.3**
IW8	10-Feb-04	Field Electrode		**13**
IW8	11-Feb-04	Field Electrode		**14**
IW8	11-Feb-04	Field Electrode		**15**
IW8	12-Feb-04	Field Electrode		**17**
IW8	12-Feb-04	Field Electrode		**16**
IW8	12-Feb-04	Laboratory		**4.1**
IW8	13-Feb-04	Field Electrode		**16**
IW8	13-Feb-04	Field Electrode		**21**
IW8	14-Feb-04	Field Electrode		**16**
IW8	14-Feb-04	Field Electrode		**12**
IW8	15-Feb-04	Field Electrode		**26**
IW8	15-Feb-04	Laboratory		**14**
IW8	15-Feb-04	Field Electrode		**25**
IW8	16-Feb-04	Field Electrode		**63**

TABLE H-1: RESULTS OF TRACER TEST (Winter 2004) ANIONS ANALYSIS.
Site 16 Landfill, LHAAP, Karnack, Texas

			Concentration (mg/L)	
Location	Date Sampled	Analysis	Iodide	Bromide
16PM07-S	24-Mar-04	Field Electrode	**24.9**	
16PM07-S	6-Apr-04	Field Electrode	**26.3**	
16PM07-S	30-Sep-04	Laboratory		**2.62**
16PM07-S	26-Jan-05	Laboratory		**3.61**
16PM08	27-Jun-03	Laboratory		**2.3**
16PM08	10-Feb-04	Field Electrode		**4**
16PM08	11-Feb-04	Field Electrode		0.500 U
16PM08	11-Feb-04	Field Electrode		**4**
16PM08	12-Feb-04	Field Electrode		**2**
16PM08	12-Feb-04	Field Electrode		0.500 U
16PM08	13-Feb-04	Field Electrode		0.500 U
16PM08	13-Feb-04	Field Electrode		0.500 U
16PM08	14-Feb-04	Field Electrode		0.500 U
16PM08	14-Feb-04	Field Electrode		0.500 U
16PM08	15-Feb-04	Field Electrode		0.500 U
16PM08	15-Feb-04	Field Electrode		0.500 U
16PM08	16-Feb-04	Field Electrode		0.500 U
16PM08	16-Feb-04	Field Electrode		0.500 U
16PM08	17-Feb-04	Field Electrode		0.500 U
16PM08	18-Feb-04	Field Electrode		0.500 U
16PM08	18-Feb-04	Laboratory		**1.2**
16PM08	18-Feb-04	Field Electrode		0.500 U
16PM08	19-Feb-04	Field Electrode		0.500 U
16PM08	20-Feb-04	Field Electrode		0.500 U
16PM08	22-Feb-04	Field Electrode		0.500 U
16PM08	23-Feb-04	Field Electrode		0.500 U
16PM08	24-Feb-04	Field Electrode		0.500 U
16PM08	25-Feb-04	Field Electrode		0.500 U
16PM08	26-Feb-04	Field Electrode		0.500 U
16PM08	27-Feb-04	Field Electrode		0.500 U
16PM08	28-Feb-04	Field Electrode		0.500 U
16PM08	01-Mar-04	Field Electrode		0.500 U
16PM08	02-Mar-04	Field Electrode		0.500 U
16PM08	03-Mar-04	Field Electrode		0.500 U
16PM08	04-Mar-04	Field Electrode		0.500 U
16PM08	05-Mar-04	Field Electrode		0.500 U
16PM08	06-Mar-04	Field Electrode		0.500 U
16PM08	08-Mar-04	Field Electrode		0.500 U
16PM08	09-Mar-04	Field Electrode		0.500 U
16PM08	10-Mar-04	Field Electrode	0.500 U	
16PM08	10-Mar-04	Field Electrode		0.500 U
16PM08	12-Mar-04	Field Electrode	0.500 U	
16PM08	12-Mar-04	Field Electrode		0.500 U
16PM08	15-Mar-04	Field Electrode	0.500 U	
16PM08	15-Mar-04	Field Electrode		0.500 U
16PM08	17-Mar-04	Field Electrode	0.500 U	
16PM08	17-Mar-04	Field Electrode		**3**
16PM08	19-Mar-04	Field Electrode	0.500 U	
16PM08	19-Mar-04	Field Electrode		**4.1**
16PM08	23-Mar-04	Laboratory		**6.65**
16PM08	24-Mar-04	Field Electrode	0.500 U	
16PM08	24-Mar-04	Field Electrode		0.500 U
16PM08	06-Apr-04	Field Electrode		0.500 U
16PM08	30-Sep-04	Laboratory		**2.53**
16PM08	26-Jan-05	Laboratory		**2.69**

			Concentration (mg/L)	
Location	Date Sampled	Analysis	Iodide	Bromide
IW8	16-Feb-04	Laboratory		**54**
IW8	16-Feb-04	Field Electrode		**97**
IW8	16-Feb-04	Laboratory		**84**
IW8	17-Feb-04	Field Electrode		**154**
IW8	18-Feb-04	Field Electrode		**205**
IW8	18-Feb-04	Field Electrode		**197**
IW8	18-Feb-04	Laboratory		**164**
IW8	19-Feb-04	Field Electrode		**169**
IW8	20-Feb-04	Field Electrode		**182**
IW8	22-Feb-04	Field Electrode		**189**
IW8	22-Feb-04	Laboratory		**150**
IW8	23-Feb-04	Field Electrode		**201**
IW8	24-Feb-04	Field Electrode		**179**
IW8	25-Feb-04	Field Electrode		**186**
IW8	25-Feb-04	Laboratory		**145**
IW8	26-Feb-04	Field Electrode		**184**
IW8	27-Feb-04	Field Electrode		**117**
IW8	28-Feb-04	Field Electrode		**142**
IW8	01-Mar-04	Field Electrode		**121**
IW8	02-Mar-04	Field Electrode		**121**
IW8	03-Mar-04	Field Electrode		**110**
IW8	05-Mar-04	Field Electrode		**82.6**
IW8	05-Mar-04	Laboratory		**59**
IW8	08-Mar-04	Field Electrode		**61.4**

TABLE H-2: RESULTS OF TRACER TEST (Fall 2005) ANIONS ANALYSIS.
Site 16 Landfill, LHAAP, Karnack, Texas

Location	Date Sampled	Analysis	Bromide (mg/L)
EW10	03-Nov-05	Sirem Lab	**11**
EW10	18-Nov-05	Sirem Lab	**6.1**
EW10	21-Nov-05	Sirem Lab	**6.3**
EW10	1-Dec-05	Sirem Lab	**9**
EW10	6-Dec-05	Sirem Lab	**6.2**
EW10	12-Dec-05	Sirem Lab	**4.4**
EW10	19-Dec-05	Sirem Lab	**4.6**
EW12	3-Nov-05	Sirem Lab	**9.2**
EW12	7-Nov-05	Sirem Lab	**822**
EW12	8-Nov-05	Sirem Lab	**762**
EW12	9-Nov-05	Sirem Lab	**772**
EW12	9-Nov-05	Sirem Lab	**665**
EW12	10-Nov-05	Sirem Lab	**681**
EW12	19-Dec-05	Sirem Lab	**3.3**
EW12B	3-Nov-05	Sirem Lab	**16**
EW12B	7-Nov-05	Sirem Lab	**797**
EW12B	08-Nov-05	Sirem Lab	**719**
EW12B	09-Nov-05	Sirem Lab	**895**
EW12B	9-Nov-05	Sirem Lab	**894**
EW12B	10-Nov-05	Sirem Lab	**694**
EW12B	20-Dec-05	Sirem Lab	**2.8**
EW13	12-Dec-05	Sirem Lab	**2.9**
EW9	03-Nov-05	Sirem Lab	**11**
EW9	19-Dec-05	Sirem Lab	**5.5**
EW9 DUP	03-Nov-05	Sirem Lab	**13**
IW1	19-Dec-05	Sirem Lab	**28**
IW2	18-Nov-05	Sirem Lab	**83**
IW2	28-Nov-05	Sirem Lab	**43**
IW2	01-Dec-05	Sirem Lab	**41**
IW2	06-Dec-05	Sirem Lab	**27**
IW2	08-Dec-05	Sirem Lab	**23**
IW2	12-Dec-05	Sirem Lab	**7**
IW2	19-Dec-05	Sirem Lab	**9**
IW3	03-Nov-05	Sirem Lab	**7.1**
IW3	8-Nov-05	Sirem Lab	**37**
IW3	09-Nov-05	Sirem Lab	**19**
IW3	9-Nov-05	Sirem Lab	**18**
IW3	10-Nov-05	Sirem Lab	**47**
IW3	11-Nov-05	Sirem Lab	**16**
IW3	14-Nov-05	Sirem Lab	**59**
IW3	16-Nov-05	Sirem Lab	**48**
IW3	17-Nov-05	Sirem Lab	**186**
IW3	18-Nov-05	Sirem Lab	**59**
IW3	21-Nov-05	Sirem Lab	**60**
IW3	23-Nov-05	Sirem Lab	**36**
IW3	28-Nov-05	Sirem Lab	**21**
IW3	1-Dec-05	Sirem Lab	**13**
IW3	6-Dec-05	Sirem Lab	**11**
IW3	08-Dec-05	Sirem Lab	**10**
IW3	12-Dec-05	Sirem Lab	**13**
IW3	19-Dec-05	Sirem Lab	**19**
IW4	03-Nov-05	Sirem Lab	**3.3**
IW4	17-Nov-05	Sirem Lab	**1.9**
IW4	21-Nov-05	Sirem Lab	**2.9**
IW4	23-Nov-05	Sirem Lab	**6.1**
IW4	28-Nov-05	Sirem Lab	**54**
IW4	1-Dec-05	Sirem Lab	**36**
IW4	06-Dec-05	Sirem Lab	**76**
IW4	8-Dec-05	Sirem Lab	**67**
IW4	12-Dec-05	Sirem Lab	**45**
IW4	19-Dec-05	Sirem Lab	**47**

Location	Date Sampled	Analysis	Bromide (mg/L)
IW5	03-Nov-05	Sirem Lab	**1.6**
IW5	28-Nov-05	Sirem Lab	**1.5**
IW5	06-Dec-05	Sirem Lab	**1.6**
IW5	08-Dec-05	Sirem Lab	**1.4**
IW5	12-Dec-05	Sirem Lab	**2.2**
IW5	19-Dec-05	Sirem Lab	**2.4**
IW6	03-Nov-05	Sirem Lab	**1**
IW6	28-Nov-05	Sirem Lab	**1.5**
IW6	06-Dec-05	Sirem Lab	**1.7**
IW6	08-Dec-05	Sirem Lab	**1**
IW6	12-Dec-05	Sirem Lab	**1.7**
IW6	19-Dec-05	Sirem Lab	**1**
IW7	19-Dec-05	Sirem Lab	**4.1**
IW8	19-Dec-05	Sirem Lab	**5.2**
PM1	2-Nov-05	Sirem Lab	**1.7**
PM1	20-Dec-05	Sirem Lab	**1.2**
PM10D	2-Nov-05	Sirem Lab	**4.2**
PM10D	8-Dec-05	Sirem Lab	**3.6**
PM10D	12-Dec-05	Sirem Lab	**2.3**
PM10D	19-Dec-05	Sirem Lab	**2.2**
PM10S	02-Nov-05	Sirem Lab	**11**
PM10S	08-Dec-05	Sirem Lab	**3.7**
PM10S	12-Dec-05	Sirem Lab	**4**
PM10S	19-Dec-05	Sirem Lab	**2.2**
PM11	02-Nov-05	Sirem Lab	**4.1**
PM11	17-Nov-05	Sirem Lab	**8**
PM11	21-Nov-05	Sirem Lab	**35**
PM11	28-Nov-05	Sirem Lab	**39**
PM11	6-Dec-05	Sirem Lab	**45**
PM11	08-Dec-05	Sirem Lab	**38**
PM11	12-Dec-05	Sirem Lab	**32**
PM11	20-Dec-05	Sirem Lab	**26**
PM12	02-Nov-05	Sirem Lab	**12**
PM12	20-Dec-05	Sirem Lab	**8.4**
PM13D	2-Nov-05	Sirem Lab	**6**
PM13D	19-Dec-05	Sirem Lab	**2.6**
PM13S	2-Nov-05	Sirem Lab	**7.1**
PM13S	19-Dec-05	Sirem Lab	**5.4**
PM14	02-Nov-05	Sirem Lab	**5**
PM14	19-Dec-05	Sirem Lab	**4.3**
PM2	2-Nov-05	Sirem Lab	**2.1**
PM2	20-Dec-05	Sirem Lab	**1.1**
PM3	02-Nov-05	Sirem Lab	**2.4**
PM3	20-Dec-05	Sirem Lab	**41**
PM4	2-Nov-05	Sirem Lab	**3.2**
PM4	14-Nov-05	Sirem Lab	**3.4**
PM4	16-Nov-05	Sirem Lab	**5.7**
PM4	17-Nov-05	Sirem Lab	**10**
PM4	18-Nov-05	Sirem Lab	**10**
PM4	21-Nov-05	Sirem Lab	**47**
PM4	23-Nov-05	Sirem Lab	**62**
PM4	28-Nov-05	Sirem Lab	**32**
PM4	01-Dec-05	Sirem Lab	**27**
PM4	6-Dec-05	Sirem Lab	**27**
PM4	08-Dec-05	Sirem Lab	**22**
PM4	12-Dec-05	Sirem Lab	**36**
PM4	20-Dec-05	Sirem Lab	**25**
PM5	2-Nov-05	Sirem Lab	**14**
PM5	20-Dec-05	Sirem Lab	**12**

TABLE H-2: RESULTS OF TRACER TEST (Fall 2005) ANIONS ANALYSIS.
Site 16 Landfill, LHAAP, Karnack, Texas

PM6	02-Nov-05	Sirem Lab	**6.1**
PM6	28-Nov-05	Sirem Lab	**2.7**
PM6	01-Dec-05	Sirem Lab	**6.3**
PM6	6-Dec-05	Sirem Lab	**4.2**
PM6	08-Dec-05	Sirem Lab	**4.7**
PM6	12-Dec-05	Sirem Lab	**4.3**
PM6	20-Dec-05	Sirem Lab	**2.9**
PM7D	2-Nov-05	Sirem Lab	**7.7**
PM7D	17-Nov-05	Sirem Lab	**5.2**
PM7D	21-Nov-05	Sirem Lab	**5.6**
PM7D	28-Nov-05	Sirem Lab	**5.4**
PM7D	6-Dec-05	Sirem Lab	**6.7**
PM7D	08-Dec-05	Sirem Lab	**5.5**
PM7D	12-Dec-05	Sirem Lab	**7**
PM7D	19-Dec-05	Sirem Lab	**3.6**
PM7S	02-Nov-05	Sirem Lab	**5.6**
PM7S	17-Nov-05	Sirem Lab	**3.1**
PM7S	21-Nov-05	Sirem Lab	**4**
PM7S	28-Nov-05	Sirem Lab	**7.8**
PM7S	06-Dec-05	Sirem Lab	**10**
PM7S	8-Dec-05	Sirem Lab	**9.3**
PM7S	12-Dec-05	Sirem Lab	**15**
PM7S	19-Dec-05	Sirem Lab	**17**
PM8	02-Nov-05	Sirem Lab	**7.8**
PM8	9-Nov-05	Sirem Lab	**57**
PM8	10-Nov-05	Sirem Lab	**327**
PM8	11-Nov-05	Sirem Lab	**470**
PM8	14-Nov-05	Sirem Lab	**67**
PM8	16-Nov-05	Sirem Lab	**103**
PM8	17-Nov-05	Sirem Lab	**32**
PM8	18-Nov-05	Sirem Lab	**28**
PM8	21-Nov-05	Sirem Lab	**28**
PM8	23-Nov-05	Sirem Lab	**16**
PM8	28-Nov-05	Sirem Lab	**7.9**
PM8	01-Dec-05	Sirem Lab	**7.8**
PM8	06-Dec-05	Sirem Lab	**19**
PM8	08-Dec-05	Sirem Lab	**8.7**
PM8	12-Dec-05	Sirem Lab	**6.4**
PM8	20-Dec-05	Sirem Lab	**14**
PM8 DUP	02-Nov-05	Sirem Lab	**8.3**
PM9	2-Nov-05	Sirem Lab	**4.6**
PM9	20-Dec-05	Sirem Lab	**3.4**